Oct. 2, 1951 E. J. RABENDA **2,569,829**

RECORD CONTROLLED PRINTING DEVICE
WITH FEED CONTROL TAPE

Filed May 3, 1949 51 Sheets-Sheet 14

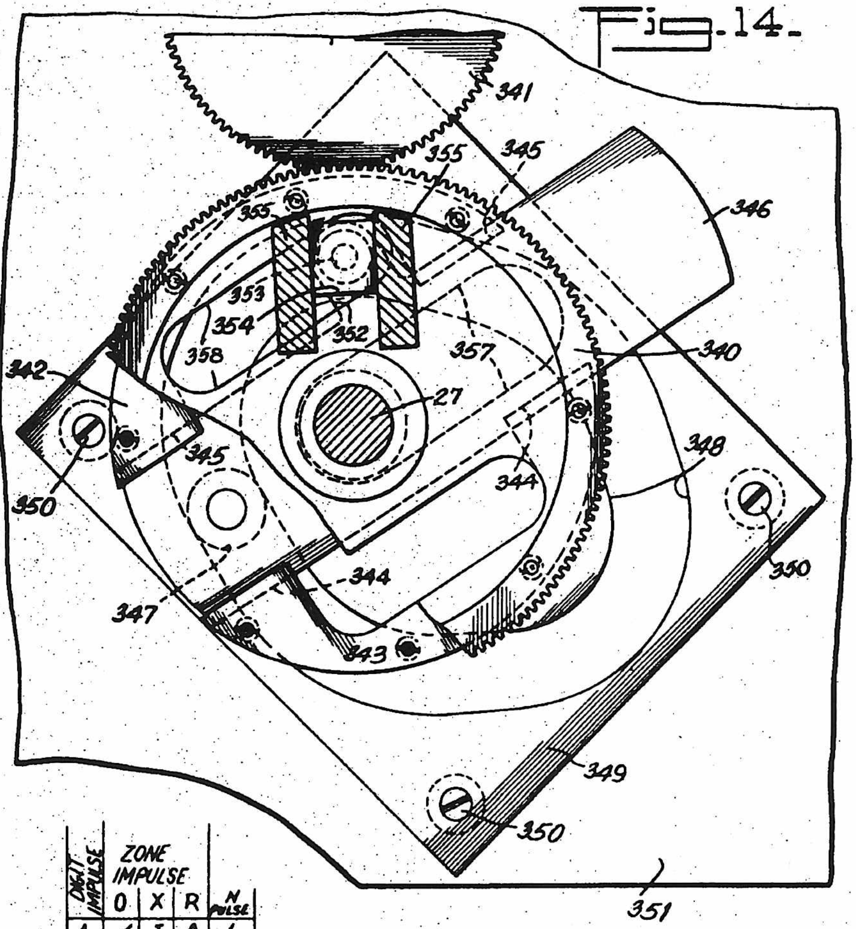

Fig. 14.

DIGIT IMPULSE	ZONE IMPULSE			N PULSE
	0	X	R	
1	/	J	A	1
2	S	K	B	2
3	T	L	C	3
4	U	M	D	4
5	V	N	E	5
6	W	O	F	6
7	X	P	G	7
8	Y	Q	H	8
9	Z	R	I	9
0				0

Fig. 15.

INVENTOR
E J Rabenda
BY
J W Armbruster
ATTORNEY

FIG. 22

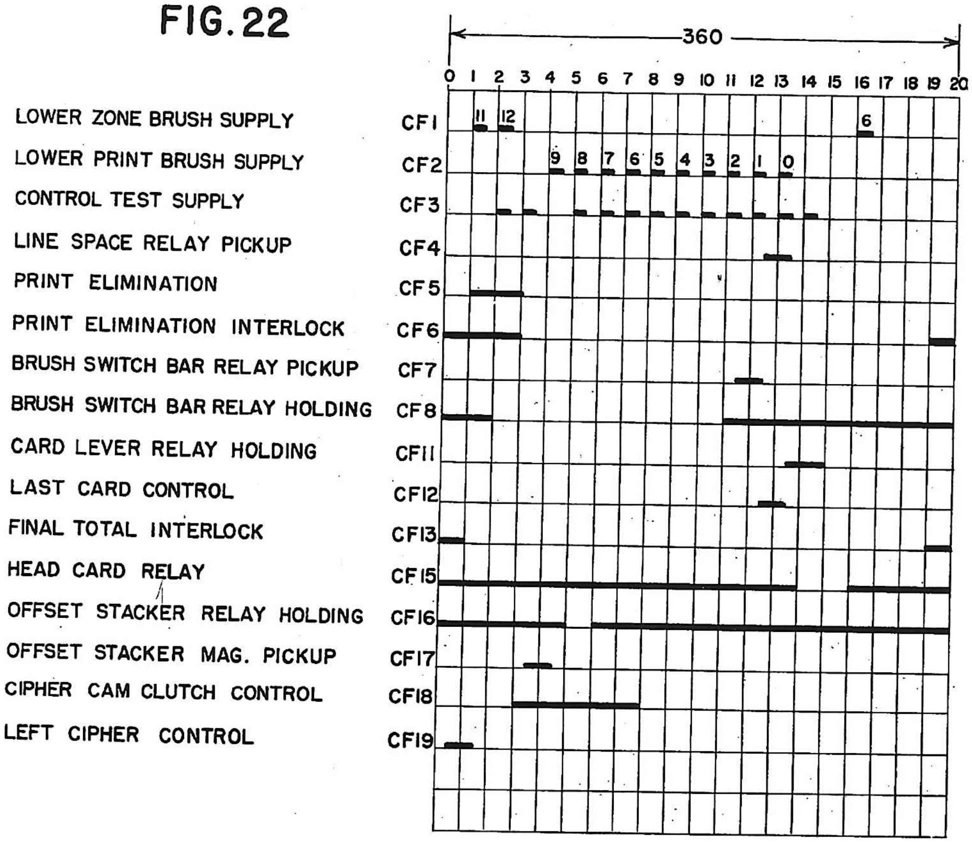
360
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
LOWER ZONE BRUSH SUPPLY CF1
11
12
6
LOWER PRINT BRUSH SUPPLY CF2
9 8 7 6 5 4 3 2 1 0
CONTROL TEST SUPPLY CF3
LINE SPACE RELAY PICKUP CF4
PRINT ELIMINATION CF5
PRINT ELIMINATION INTERLOCK CF6
BRUSH SWITCH BAR RELAY PICKUP CF7
BRUSH SWITCH BAR RELAY HOLDING CF8
CARD LEVER RELAY HOLDING CF11
LAST CARD CONTROL CF12
FINAL TOTAL INTERLOCK CF13
HEAD CARD RELAY CF15
OFFSET STACKER RELAY HOLDING CF16
OFFSET STACKER MAG. PICKUP CF17
CIPHER CAM CLUTCH CONTROL CF18
LEFT CIPHER CONTROL CF19

FIG. 22a

BRUSH IMPULSE		11	12	9	8	7	6	5	4	3	2	1	0
PRINT	DIGIT			9	8	7	6	5	4	3	2	1	0
	11 & 12			Z	Y	X	W	V	U	T	S	@	%
	12			I	H	G	F	E	D	C	B	A	—
	11			R	Q	P	O	N	M	L	K	J	#

INVENTORS
Fred M Carroll
BY Arthur F Smith
John W Armbruster
ATTORNEY

May 27, 1952 A. B. CROWELL **2,598,511**

TRANSLATING DEVICE FOR RECORDING MACHINES

Filed Aug. 13, 1947 16 Sheets-Sheet 13

CHARACTER	HOLES			SET PINS —					
9		9						5	6
I	R	9		1				5	6
Z	O	9			2			5	6
R	X	9		1	2			5	6
8		8							6
H	R	8		1					6
Y	O	8			2				6
Q	X	8		1	2				6
7		7				3		5	
G	R	7		1		3		5	
X	O	7			2	3		5	
P	X	7		1	2	3		5	
6		6						5	
F	R	6		1				5	
W	O	6			2			5	
O (ALPH)	X	6		1	2			5	
5		5					4	5	
E	R	5		1			4	5	
V	O	5			2		4	5	
N	X	5		1	2		4	5	
4		4					4		
D	R	4		1			4		
U	O	4			2		4		
M	X	4		1	2		4		
3		3				3	4		
C	R	3		1		3	4		
T	O	3			2	3	4		
L	X	3		1	2	3	4		
2		2				3			
B	R	2		1		3			
S	O	2			2	3			
K	X	2		1	2	3			
1		1				3			6
A	R	1		1		3			6
/	O	1			2	3			6
J	X	1		1	2	3			6
O (ZERO)	O				2				
&	R			1					
#	O	3	8		2	3	4		6
—	X			1	2				
*	O	4	8		2		4		6
**	R	3	8	1		3	4		6
.		4	8				4		6
%	X	3	8	1	2	3	4		6
@	O	3	6		2	3	4	5	
,	X	4	8	1	2		4		6

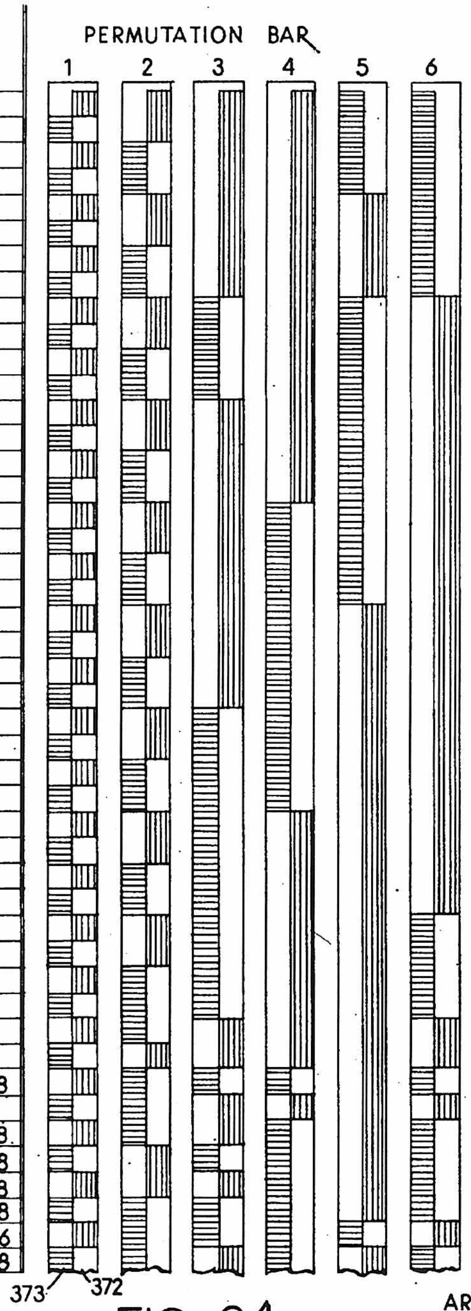

FIG_ 24_

INVENTOR
ARNOLD B. CROWELL
BY Geoffrey Knight
ATTORNEY

Remington Rand, Inc. Electronic Computer Dept.

PROGRAMMING
FOR THE
UNIVAC FAC-TRONIC SYSTEM

January 1953

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ECKERT-MAUCHLY DIVISION

PRICE $18.5

EL 192 B PRINTED IN U.S.A.

SECTION 17 – UNIVAC PULSE CODE

ZONE	XS3															
	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
00	I̸	Δ	–	0	1	2	3	4	5	6	7	8	9			
01	R̸	,	.	;	A	B	C	D	E	F	G	H	I			
10	T̸		⊠	/	J	K	L	M	N	O	P	Q	R	L̸		U̸
11	P̸	B̸			+	S	T	U	V	W	X	Y	Z	Ø		

I̸ = IGNORE
Δ = SPACE
R̸ = CARRIAGE RETURN
T̸ = TAB
L̸ = SHIFT LOCK

U̸ = UNSHIFT
Ø = ONE SHIFT (SINGLE SHIFT)
P̸ = PRINTER STOP
B̸ = PRINTER BREAKPOINT STOP
⊠ = NOT AVAILABLE (USED INTERNALLY)
BLANK SQUARES NOT USED.

NOTE – IN GENERAL, UNITYPER HAS A STANDARD KEYBOARD, BUT OTHER TYPEWRITER SYMBOLS CAN BE, AND HAVE BEEN PROVIDED.

The Transmission of Intelligence in Typescript

I. S. COGGESHALL

THIS is not a paper on Modern Communication Theory, although some of the precepts of MCT will be referred to. Rather, the presentation is more in the nature of a survey of the practical aspects of encoding and transmitting intelligence in the form of typescript, which, by and large, is the problem and the business of the telegraph companies, wire and radio, domestic and international. In a sense, then, this paper may be considered prologue to MCT—locating, in a manner of speaking, the points of departure from which the new mathematical theories may lead the communication arts to new attainments and usefulness.

PART I — THE EVOLUTION OF TRANSMISSION

The basic statements of the philosophy of transmitting information in the presence of noise interference have been mathematically demonstrated by Shannon, who showed[1] that the upper limit of the amount of information, measured in binary units per second (C) which ideally can be transmitted in one direction over a transmission system, in relation to the bandwidth (W) expressed in cycles per second occupied by the system, in the presence of Gaussian white noise of average power N, is related to the average received power (P) in the signal, in the relationship:

$$C/W = \log_2\left(\frac{P+N}{N}\right) \text{ or } C = W \log_2\left(1+\frac{P}{N}\right)$$

Hartley[2] had addressed himself to the total amount (S) of all the information transmitted over frequency range W in time T, which he found to be constant in the relationship $S = k\,W\,T$. Since $S/T = C$ in the new terminology, $C/W = k$. By relationship of bits to cycles per second, $k = 2$. In the new formula, $C/W = 2$ when $P/N = 3$, from which it appears that the old idea meets the new one as a special case.

The derivation of the new formulas of MCT, (and there are many of them in addition to the one cited), was forced upon communication specialists by the inadequacy of former theories to explain P/N relationships in the bursts of power characteristic of radar and other pulsing techniques, and to account for the ability of forms of wide-band transmissions, like FM, to override noise. The development of the new mathematical theories has involved the abstractions of multidimensional space[3] in fitting the informational content of messages and pictures to the informational capacity of systems to transmit them; and has given communication engineers new design ideals even before the full implications of the formulas and their correlatives are thoroughly appreciated. For example, the equation cited contains a signal/noise ratio, the stepping-up of which, either by expedients of increasing received signal power or of mitigating interference, the engineer knows a great deal about already and is now impelled to learn more; because, if a high ratio of P/N can be doubled in db, W can be halved without degrading the circuit, or if W is held constant, the informational carrying capacity of a circuit can be doubled.

A figure of 30 db separation between average received power and average noise is not unrepresentative of modern commercial communication circuits.[4,5] It may be worth while going through an example, step by step, to see what doubling P/N means. In the MCT formula, P/N is in power units, but the theorem is that bandwidth can be halved if P/N is doubled in decibels. Now, 30 db means $P/N = 1000$ in power units; doubling it to 60 db means increasing power units to $P/N = 1{,}000{,}000$. (For odd values, see handbooks[6]). If N is held constant while P is doubled in db, the received signal will have increased in the ratio 1000000/1000, or one-thousand times. In the formula, $\log_2 x$ may be replaced by its equivalent, $3.3 \log_{10} x$. In doubling P/N, the value of the log term has thus gone up from $3.3 \log_{10} 1001$ to $3.3 \log_{10} 1000001$, or from 9.9 to 19.8. With W held constant, a thousandfold increase in power thus might result in the approaching of a doubling of traffic capacity in the case of an ideal circuit; or, without increasing traffic capacity, the transmission band might be compressed to half width.

The respect given the possibilities expressed by this equation has already spurred a frontal attack on the narrowing of the prodigious bandwidths required by television and color TV, and is reflected in the work being done along other lines, including detecting the existence of radar signals through random noise[7].

There is aesthetic charm in a discovery like this, which, while profound, nevertheless can be couched in terms of a simple equation, demonstrating anew the mathematical formulation of Nature around what Copernicus termed "an orderly arrangement . . . a wonderful symmetry."[8] In another profound and extremely simple expression, $c^2 = e/m$, Einstein keyed the transformation of matter into energy[9], that led modern physics by logical steps to the atomic bomb. But it is worth observing that the indebtedness of nuclear science to Einstein is entirely different, as to mass-energy transformations, from that of the steam engineer, to whom Boyle's Law still represents Truth, within the ranges of refinement of his observations, measurements, and day-to-day requirements. In like manner it may prove that Modern Communication Theory, already finding its greatest potential applications in the vast bandwidths of television, will confer only minor gains on practical typescript communication. Nevertheless this must not be assumed: no engineer with discernment is assuming it.

The transmission parameters governing important segments of the world's work in telegraphy may be variously classified. As to the medium of transmission, we have wire, radio, and (as an incidental component) wave-guides. The media, largely, determine the d-c or carrier frequencies employed, starting with non-repeatered submarine cables on the low end and proceeding up through loaded and coaxial submarine cable, underground cable, open-wire lines, MF and HF radio, and coaxial cable, to SHF radio beams. As to the type of modulation, AM leads, FM is important, as is FSK[10], and there have been some probings with PAM[11] and PPM[12]. The number of quantized power levels is largely limited to two, although three are used on submarine cables, and historically quadruplex d-c telegraphy might be considered a form of transmission at four power levels.

To consider all the combinations of the parameters listed would be the function of a book rather than a technical paper, so only a few can be chosen. Those, in turn, can be considered in relation to only a restricted number of the subjects included within the scope of MCT. The best place to begin would seem to be in the great gulf fixed between radio and wire transmission.

Power and Noise

When a square-topped wave front of voltage is impressed on a wire, cable, or loop by closing the circuit or reversing the potential at the transmitter, the instantaneous change produces a transient surge of power which can be represented as a continuous spectrum of Fourier harmonics[13], the amplitudes of which will be attenuated, and their speed of propagation along the line will be retarded, both directly but non-linearly according to frequency, by the resistance, capacitance, inductance, and leakance of the line and the characteristics of the terminal equipment. (See Figure 1, top.) Attenuation, delay, lack of refinement in receivers, noise, and especially loading combine to establish a virtual cut-off frequency, f_c, that to all intents and purposes establishes an upper limit to the pass-band—all frequencies below it, down to zero, being to some extent present in the slope of the no-longer-vertical amplitude/time wave front as it arrives at the far end of the circuit. The higher the cut-off frequency of the system, the richer the high-fre-

A paper presented before the IRE Technical Conference on Communications, Cedar Rapids, Iowa, September 1952.

Western Union Technical Review vol 7 #1 January 1953 quency content of the arrival curve[14], the steeper its slope; and the steeper its slope the shorter the time-base, $t=1/2f_c$, which spans its rise from zero to maximum. This slope cannot be made steeper by a linear amplifier, for that would merely change the value of the maximum without changing its timing, or the duration of t. The slope can be changed by use of networks which will attenuate the low and emphasize the high-frequency components of the signal; and which will slow down early-arriving low-frequency components until the higher frequencies arrive to be effectively in-phased with them[15, 16].

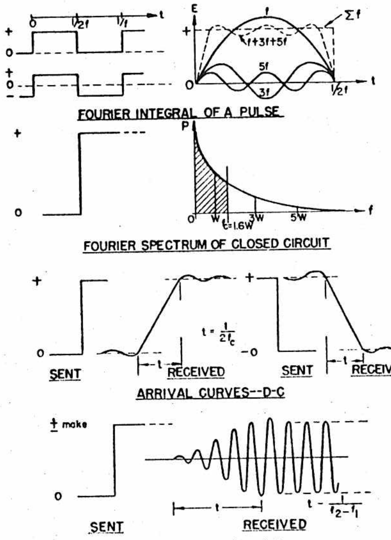

Figure 1

This art is called "shaping" the arrival curve by selective amplifications and phasing, and is important to cable operating speed. For it is evident that within the transmission limitations of the cable set by its construction—the amount of money which was put into the copper conductor; the dielectric constant and thickness of the insulation chosen from among the exceedingly few practicable materials available; the characteristics of the inductive loading, if any; and the nature of the earth-return—all of which collectively determine f_c—only by reducing t can W and C be increased, P/N being held constant.

As a matter of fact a submarine cable which will shape signals satisfactorily so that transmission can be maintained at 20 cps must deal with all frequencies from zero up to 32 cps; that is, $f_c = 1.6\ W$. It is customary to quote landline and cable speeds in terms of W rather than f_c, but the modest margin for harmonics must be guarded.

Turning attention now to radio, the medium presents to the establishment and maintenance of a continuous sinusoidal wave no such impediments as wire lines offer. Even after several revolutions around the earth the high-frequency carrier is protected from amplitude and velocity distortion. In that respect radio transmission conditions may be looked upon as uncircumscribed.

The sudden interruption of an a-c carrier, or its reestablishment, cannot, however, be accomplished without transient build-up and decay of amplitude and variations of phase due to the terminal equipment necessary to operation. (See Figure 1, bottom.) It can be shown[17] that for the comparatively narrow bands used in telegraphy the time of this transient $t = 1/(f_2 - f_1)$, the upper and lower limits of the pass-band. This time is twice as long as the time-base of a d-c arrival curve, $t = 1/2f_c$, indicating that for equal intelligence bandwidths, d-c telegraphy will convey more C in the same W than will carrier modulation, under the same conditions of P/N. However, this is of no moment in the frequency ranges where MCT operates, and it is entirely negligible in the realm of radio-frequency carriers.

The number of cycles of carrier embraced within the envelope of a single informational pulse may be of importance in the case of a short submarine cable, but negligible in transoceanic radiotelegraphy. A short submarine cable section between Nova Scotia and Newfoundland[18] is capable of transmitting a carrier of 80 cycles in one direction and 50 cps in the other, both being modulated at three quantized amplitude levels at 7.5 cycles per second. $50/7.5 = 6.6$. The pulse envelope contains 3.3 cycles. By contrast, a transoceanic HF radio circuit on 18 mc is operated by Continental Morse at 150 words/minute, or 60 cps. $18{,}000{,}000/60 = 300{,}000$. The pulse envelope embraces 150,000 cycles of carrier.

Because of the differences between their transmission media, radio and wire[19] requirements for power are rich in contrasts. The dbm level of reference to power of 1 milliwatt indicates the order of magnitudes employed in landline telephone practice. Transpositions of pairs and shielding of circuits in underground cables has minimized noise to the extent that little if anything would be gained by raising power levels. Power falls off at the rate of approximately 0.05 db per pair mile at 1000 cps, which would total 10^{45} in power ratio loss (450 db) between points 900 miles apart, like New York and Chicago. As Osborne[20] has said, with the usual telephone input of about one milliwatt, were there no intermediate amplification in the circuit, "it would deliver only one electron in each two months, and even if all the power available in New York City or Chicago could be used at the input without burning up the circuit, the received current would be utterly inappreciable."

On the transatlantic section of a London—New York cable[21] formerly operated at 6.25 cps (Figure 2) with a transmitting voltage of 90, delivering to the cable an input power of 35 dbm, or 3 watts, the attenuation over its 2148 nautical miles of length was 0.034 db per mile, or 72 db over all, delivering signals at a power level of minus 37 dbm at the Newfoundland station repeater input, (curve A). This was ample to override by 21 db the noise present in the input at the station. Sufficient gain (72 db) was supplied by the station amplifier to raise the received signals to the 3 watts (35 dbm) required to operate the sending-on relays. It having been calculated that 99.9% of the noise (in terms of voltage) present in the signal at the station was the result of exposure over the last 150 miles of shallower water, it was decided to lay a repeater in deep water beyond that point, to lift the gain and override the interference which would be picked up on the shoreward end. The lower curve (B) shows the results of the final design. Transmitting voltage was lowered to 60, the input being 33 dbm or 2 watts. The speed of transmission was increased 233 percent from 50 words per minute to 167 wpm (20.83 cps). Attenuation went up accordingly, to 0.055 db per mile. If the signals were carried on to the terminal at that speed they would have been masked by the noise by 27 db. As they now reach the submerged repeater input, their level is minus 73 db. The repeater gain is 52 db. The signal then suffers attenuation and reaches Newfoundland at minus 30 dbm, or with an improvement of 7 db at the better than tripled speed.

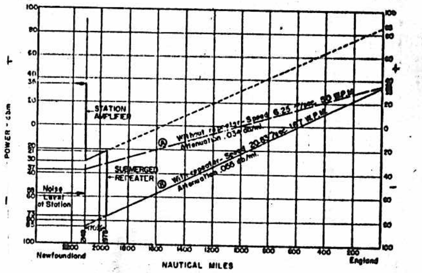

Figure 2

To have arrived there by increasing power at the transmitting point is depicted by the dotted upper curve of Figure 2. The sending level would have to be 85 dbm, or 316 kw, an obvious absurdity for cables ordinarily worked at 3 watts. Although cable insulation will withstand 40,000 volts on test before being laid, the hydrostatic pressure to which cables are subjected introduces mechanical hazards which are translated into possible lowered insulation. On account of high investment and repair costs, practice is very conservative as to voltages applied, and they rarely exceed 110 volts. The fastest cable across the Atlantic is permalloy loaded; its permeability characteristics limit the initial current permissible, so that less than 50 volts are applied to the cable[22].

Reference to power levels in kilowatts brings to mind the case of radio, where the chief deterents to raising power as high as possible in conventional AM and FSK transmitters are those of economics of design, construction cost, power consumption, and interference with other services. Cross-modulation products in the amplifiers produce sidebands of widths[23] greatly in excess of those associated with the relatively narrow informational bandwidths carried, including their requisite harmonic content. In the crowded portions of the commercial radiotelegraph spectrum, spectacular increases of power to gain bandwidth in accordance with modern communication theory will be approached cautiously, and if adopted will probably involve radical changes in design along the lines of pulse modulation. It is a great pity that in this one branch of telegraphy which might profit most by increases in P/N, power is expensive and its use beset with difficulties not present in wire transmission or when radio is confined to a line-of-sight beam.

Radiotelegraphy, like wire and cable telegraphy, ends transmission with the necessity of moving a relay to key its tone circuits at a level of, say, 35 dbm, (3 watts). In the absence of repeaters enroute, the required lift is concentrated in the final receiver amplifier. The P/N ratio is a function of the initial antenna power and the combined efficiency of the sending and receiving antenna arrays and reflectors. Only in the SHF quasi-optical bands is man-made and natural noise low, and transmission weakened only occasionally by local meteorology. In the rest, that is the most, of the record radio communication spectrum, carrier frequencies are critical with respect to diffraction through and reflection from the Heaviside layers, causing certain of them, depending upon the height, ionization, turbulence, and other characteristics of the layers, either to dissipate their power enroute or to establish multiple transmission paths of different lengths which set up wave-front interference patterns. These phenomena, if the intelligence band be wide, apply unequally to the intelligence frequency components at its extremes, giving rise to selective transmission discrimination[24, 25] among the modulated channels on the carrier.

Apart from these fluctuations, which are real and annoying to the operating people, radio's high-frequency carriers form the ideal vehicle for modulation with utmost freedom. It is true that, since wire transmission got away from variable leakage by getting off open wire lines into aerial and underground cable, it has been left with few natural amplitude variations that proved devices like temperature-operated automatic gain controls[26] won't cure. But in speeding up their lines for the establishment of a-c carriers dictated by the necessity of flexibility in handling telegraphy and telephony on the same plant, engineers have been hard put to secure the advantages which radio inherently enjoys. By the insertion of repeaters as closely spaced as may be required—250 miles, 50 miles, 8 miles, 4 miles—the ever higher cut-off frequencies of shorter and shorter sections have been made the determinants of the main line itself, power has been kept low, and P/N ratios acceptable. Lines have had to be equalized and standardized, frequency components phased and shaped, sending-end and receiving-end cross-fire eliminated, the advantages of inductive loading brought into proper relationship with its effect in retarding propagation, echoes suppressed and singing eliminated, power-line inductive disturbances rendered impotent, the circuits shielded from lightning and the plant from electrolysis, abrasion, and termites. It is a tribute to communication engineering that wire and radio media can be so closely comparable in effectiveness as they are in today's coaxial cables and SHF radio beams.

Sequential Codification

Modern communication theory concerns itself not only with manipulation of P/N and W; but, as to C—the number of informational pulses to be transmitted per second—it turns a searchlight on the historicity of the pulse sequences transmitted, to ascertain whether they contain statistical properties of movement that can be built into transmitters and receivers, alike, so that only the residue beyond the momentum of each sequence occupies bandwidth in transmission. Let us make our terminal apparatus more complex if necessary, says MCT, in order to minimize the number of pulses transmitted.

In a television picture, for example, the sequence of amplitudes representing the tones of gray, from black to white, on one horizontal line of scanning are pretty much what they were on the preceding line. Let the transmitter and receiver, then, contain identical memory devices, so that only the plus and minus increments in shade from line to line need be transmitted over the air[27]. At the transmitter, encode these increments in a quantized code which is nonuniform in time-length, sending the smallest increments (which predominate) in the shortest time intervals, and reserving maximal-timed code groups for abrupt transitions between white and black. This will result in a telescoping of the information before it is transmitted over the communication channel. At the receiver, with the same previously-scanned line available in its memory device as a moving point of reference, let the received information, quantized as to increments, be decoded, expanded into uniform time elements, projected on the screen, and stored in the memory for use on the following line.

Calling that process vertical prediction, a similar observation can be made of, and treatment given to, horizontal prediction; for here again, for the most part, the amplitude representing the gray level of one picture element is pretty much an extension, in slope, of the two elements which preceded it on the same line of scan. Only the incremental slope need be signaled, and that can be done in a short nonuniform code, as before. Finally, the horizontal and vertical predictions can be given an integrated treatment, called planar, and the code for signaling the increments be further compressed.

What is being taken advantage of, here, is the statistical quality of gray-level history and movement in a TV picture. In the same way, says MCT, we ought to be able, in the transmission of intelligence in typescript, to take advantage of what a transmitter and printer can be made to learn and remember about the sequence of letters in the English language[28]. From the viewpoint of MCT a uniform 5-unit, mark-space code like printer Baudot is an anachronism, not only because the letters E and Z each contain five pulses regardless of the fact that E is frequently and Z seldom transmitted, but because, having transmitted in succession a word-space and the letter Q, it assigns five units, instead of one unit or no unit, to the letter U, which is almost certain to follow. In other words, MCT frowns upon a code so long that, after each letter is printed, it insists on reserving needlessly a full measure of spectrum for all eventualities, most of which seldom occur. Deal not in single letters but in digraph and trigraph sequences, says MCT, and reserve your longest code groups for the greatest departures from normality; telescope your information at the transmitter; don't signal the letters, signal the departures; and at the receiver, expand while you decode, thus saving bandwidth on the line.

The forfeiture of terminal apparatus simplicity for reduction of bandwidth on the main line is not a prospect which practical telegraph men will embrace without a long second look. Over the years, a great many attempts have been made to strike a balance between shortening codes and designing trouble-free terminal equipment.

Part II — Telegraphic Codification, the final installment of this article, will trace these historical steps and discuss the lessons derived from the experience.

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Biography and picture of **Mr. Coggeshall**, who is now Director of Planning, International Communications Department, appeared in TECHNICAL REVIEW for January 1951.

A Switching System for Dispatcher Test Wires

P. R. EASTERLIN

WITH the rapid growth in the last ten years of direct reperforator circuits between all areas, and the tremendous expansion in nationwide patron switching lease networks, the need for more flexible use of dispatcher test wire circuits has become increasingly apparent. These circuits, the majority of which are Morse, are used for urgent direct communication between divisional dispatchers, wire chiefs and repeater attendants in directing and coordinating the vast arteries of Western Union's land-line facilities. For example, the occasional land-line or carrier equipment failure on transcontinental circuits sometimes requires the prompt designation by the dispatcher of alternate facilities for each telegraph circuit, or perhaps the interruption of a nationwide patron circuit may require the immediate attention of wire and repeater attendants in several widely separated offices throughout the country at the same time.

Heretofore, the majority of the dispatcher circuits have been permanently terminated on a sectional basis using various types of available repeater sets which lack the flexibility of easy interconnection or rapid cut-through to other test wires. In certain instances this necessitates the relaying of emergency instructions through one or more centrally located dispatchers. However, the growth of overland reperforator and lease circuits has resulted in a frequent need for testing and regulating communication between attendants in distantly located offices to be performed on a nationwide basis for prompt maintenance and restoration of these telegraph channels.

To meet this need and also provide for the future requirements of an integrated and versatile dispatcher test wire system, a simple switching arrangement has been developed which permits offices on one test wire to select remotely and to interconnect to a maximum of 22 different test circuits terminated at a central switching office. This is accomplished by these offices transmitting prescribed selection signals either from a Morse telegraph key or by using character combinations on a standard teleprinter keyboard. This flexibility, coupled with an easy method of manually interconnecting these test circuits at all offices, is expected to result in an over-all decrease in the amount of telegraph facilities required for dispatching purposes. This article describes this new equipment, designated as Network Switching System, Plan 101-A, which is now being assembled for installation in offices throughout the system.

THEORY OF EXISTING NETWORK REPEATERS

Before describing the operation of this system, it will be helpful to review briefly the theory of a repeater circuit presently in use for combining three or more telegraph branches into one circuit at a central or hub office. Figure 1 shows the standard grouping arrangement widely used by Network Repeater 4617, and in modified form by older repeaters, whereby a number of line circuits are terminated and combined into one half-duplex circuit, providing singular transmission and re-

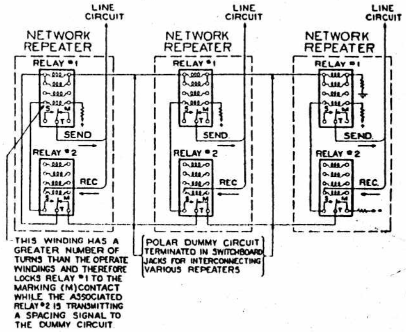
LINE CIRCUIT
LINE CIRCUIT
LINE CIRCUIT
NETWORK REPEATER
NETWORK REPEATER
NETWORK REPEATER
RELAY #1
RELAY #1
RELAY #1
S
M
T
SEND
SEND
SEND
RELAY #2
RELAY #2
RELAY #2
REC
REC
REC.
THIS WINDING HAS A GREATER NUMBER OF TURNS THAN THE OPERATE WINDINGS AND THEREFORE LOCKS RELAY #1 TO THE MARKING (M) CONTACT WHILE THE ASSOCIATED RELAY #2 IS TRANSMITTING A SPACING SIGNAL TO THE DUMMY CIRCUIT
POLAR DUMMY CIRCUIT TERMINATED IN SWITCHBOARD JACKS FOR INTERCONNECTING VARIOUS REPEATERS

Figure 1. Theory of dummy circuit used on existing repeaters to interconnect a number of line circuits into one half-duplex network

The Transmission of Intelligence in Typescript

I. S. COGGESHALL

IN THE INITIAL installment of this article it was shown that Modern Communication Theory (MCT), which is essentially mathematical in concept, considers the transmission of intelligence in typescript, or alternatively, as an extreme case, in the form of television images, merely as two special cases of the common problem of electrically forwarding informational data within available bandwidths in the presence of noise. It was shown that bandwidth requirements might be reduced in fact, at the expense of simplicity of sending and receiving equipment, by incorporating into the terminal apparatus high-speed analytical, memory, and prediction devices which would make it unnecessary to transmit a great deal of the total informational data over the line or through the transmission medium itself.

PART II — TELEGRAPHIC CODIFICATION

Important to the accomplishment of this objective is the idea of telescoping information by automatically encoding and decoding it. MCT contributes the suggestion, for example, that in transmitting plain language, the code for any given letter be not of fixed length as in Morse and Baudot codes, but vary in length, from place to place in the message, in inverse proportion to the frequency of occurrence, in English, of the digraph or trigraph sequences of which the given letter is the last.

Practical telegraphy, compelled to strike a working balance between shortening codes and designing trouble-free terminal equipment, has contented itself with the simpler mechanisms associated with fixed relationships between typescript characters and their mark-space binary representations.

The urge to conserve bandwidth, by code economies or otherwise, varies widely with types of circuit. When the long distance telephone is used for 125 words per minute by allocation of a v-f band of 4000 cycles, the spectrum usage is at the rate of 640 pulses per character. Where conductor pairs cost as much for teleprinter speeds of 23 cps as for full voice-frequency bandwidths, as they do within a city, there is no incentive to compress more information into fewer bits; and in such a case it is advantageous to ignore bandwidth, even to the extent of shifting from narrow-band printers to wide-band facsimile for collateral advantages. For the same lack of incentive one would not expect the telephone company to employ Vocoders[29] on local calls.

But when it comes to intercity and international telegraphy, economics bars the general use of wider bandwidths than are essential to convey information, and here the utility of a possible code shorter than 5 impulses per letter becomes of passing interest. MCT says that in an extreme case, the figure can be brought down to approach 2 impulses per letter, using the customary two levels of power[30].

The term *passing interest* has been used advisedly, because, so lightly are present-day circuits loaded with information in the sense that MCT looks for increased efficiency, that saving 3 out of each 5 impulses by shortening the code is of small moment. Over a period of years, time-division multiplexes, which formerly were common[31], divided bandwidths as though with a pair of dividers at 5 units per letter. Then start-stop 7½ and 7-unit code printers were adopted on the score of making channels more flexible. Were the industry interested in saving bandwidth at the cost of making its termnial equipment a little more complicated (the situation contemplated by MCT) it could do so by reverting to time-division multiplex. Instead of assigning a telegraph channel, spaced 150 or 170 cycles apart from its neighbors in a v-f band, to a single start-stop teleprinter, a 40-cycle, 3-channel, 60-wpm per channel multiplex could be substituted with a C/W gain of 300 percent. That would be only the beginning, for there is little doubt that the substitution of new types of electronic for mechanical distributors would make it possible to do away with most of the filtering losses which honeycomb our present wide-band telegraph spectra. Who could gainsay our ability to do it who watches the sweep of the electron beam in TV drop information much more complicated than mark-space into each one of 250,000 allocations on the screen during each interlaced frame? And who could deny the thesis that devotees of MCT should look in that direction for telegraphic progress, rather than in some other, when a present-day 150,000-cycle carrier system, for all its efficiency in stacking channels by translation[32], will accommodate only 576 one-way start-stop channels the informational content of which, at 5 units per character and 6 characters per channel-second, is only 17280 bits, or 8640 cps? Half this information, in one direction, may be the entire informational content of a 4-kmc unidirectional radio beam (4,000,000,000 cps) carrier[33], whose chosen frequency is a function of transmission requirements rather than a tight fit to the informational load to be carried.

In another department of telegraphy, that applying to long ocean cables, informational binaries are more closely packed into the available transmission bandwidths than anywhere else in electrical communication. The combined informational bandwidth of all 18 eastbound channels operated by all the cable companies across the North Atlantic before the advent of submerged repeaters was only 270 cps, and on it was carried 60 percent of the commercial eastbound traffic load to Europe, Africa, and the Near East, the rest being handled by radiotelegraph. Here existed, indeed, a measure of compulsion to conserve W and to compact C! Every scheme that ever occurred to anybody before MCT seems to have been tried to shorten codes[34]. The principal ones adopted have been Morse, Baudot, and their variants (See Figure 3).

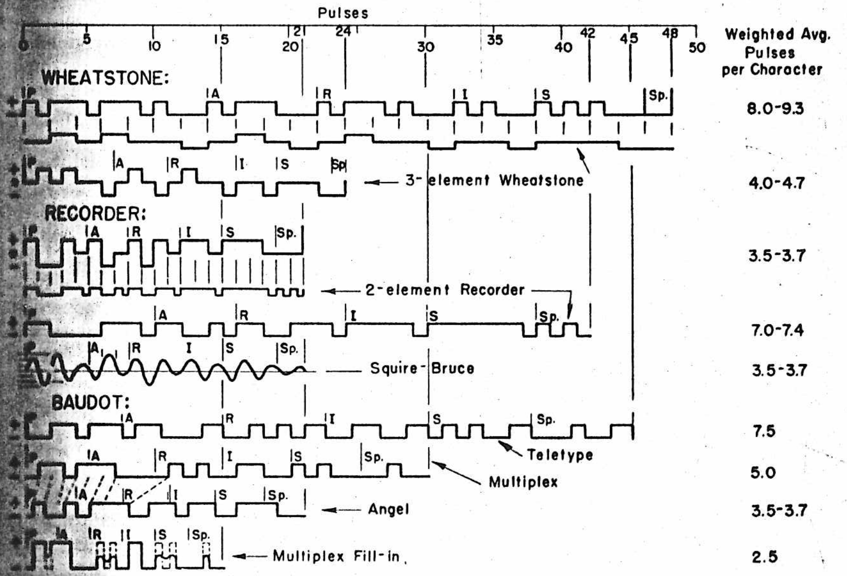

Figure 3.

A paper presented before the IRE Technical Conference on Communications, Cedar Rapids, Iowa, September 1952.

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Wheatstone Morse

The Continental version of Morse appears in two important forms, Wheatstone and Cable Recorder, both nonuniform in length of characters and both expressed in the same code of dots and dashes but transmitted in a different complex of time intervals and power levels. The length of the various characters in both versions bears a good inverse correlation with frequency of occurrence of letters in English, letters of the frequently employed ETAOIN series containing the fewest dots and dashes per letter; in conformance with MCT *in A.D. 1844!* When Continental transmission was mechanized by Wheatstone to send open-close, or plus-minus, to line, his transmitter attached to the dot an extra binary to separate it from the dot or dash next following in the same letter, making a dot 2 pulses in length; with a like separation-binary, the dash became 4 pulses long; the extra space separating letters from each other, 2 pulses; and the space separating the final letter of one word from the first of the next, 2 additional pulses. Applied to the word *PARIS* followed by its word-space, the six characters (five of them printed) aggregate 48 pulses, or 8 pulses (4 cycles) per character. This happens to be the average, weighted for frequency of occurrence, of all letters and spaces appearing in English. 100 words per minute Wheatstone = 600 characters per minute = 10 characters per second = 40 cps = 80 bauds. The figure to remember is 8 pulses per character, (sometimes called 8 units, or 8 dots, per letter). The figure rises to 9.3 when figures, cipher, and punctuation occurring in cable traffic are included.

Wheatstone Morse is widely used in radiotelegraphy. Applied to cables its length is intolerable. But a variant has been used by the British on some of their shorter cables based on the observation that, when machine-punched, Wheatstone Morse contains only three combinations of binaries in pairs: mark-mark, space-space, and mark-space (space-mark being absent). This suggested 3-level encoding (positive, zero, negative) at half the Wheatstone length, namely, 4 pulses per letter. This average is better than Baudot's 5 pulses per letter. The conversion of power levels from 2 to 3 and reverse, and the pulses from pairs to singles and reverse, can be accomplished automatically at the points where landlines are repeatered into cables and vice-versa, so that operation is regular Wheatstone Morse from landline terminal to terminal, so far as the operators are concerned. The same trick can be turned on radio using two frequencies, both of them on-and-off. The joining of coded impulses in pairs, and the employment of additional quantized power levels when P/N conditions permit, are good MCT; so was the original observation that space-mark can be considered absent in Wheatstone tape.

Cable Recorder

While dating back to the beginnings of cable operation, the cable recorder variant of Continental Morse is extraordinarily short and efficient. Dots and dashes are of the same length, 1 pulse, differing only in electrical polarity as transmitted, there being no time interval between dots, between dashes, or between dots and dashes, of the same letter; a time interval of only 1 pulse (zero potential, cable earthed) for the space between letters; and 2 such pulses, additionally, between words. The word *PARIS* with its accompanying word-space, 21 pulses, averages out at 3.5 pulses per character; the figure rises to 3.7 for run-of-mine cable traffic.

Cable recorder code is used by Cable and Wireless, the British system, throughout the world[35], it being amenable both to undulator transcription by a typist-operator and to direct printer operation. It is also used by All America on its South American cable system and is printed arrythmically on standard 5-unit printers by the Woodward-Connery system of conversion[36]. Western Union at New York converts Cable and Wireless' cable recorder signals from Latin America to 5-unit Baudot by a system involving temporary tape storage, (an informational *surge-tank*), and cadenced printing, which is also good MCT.

Three-element, or three-level, cable recorder code, handled as such by the operators, can be automatically converted for radio transmission into what is called "Higgitt" code, of double the length (i. e., 7 pulses per character), and twice the frequency by "double current," mark-space, transmission. This is the same in principle as the cable variant of Wheatstone already described, but a shorter code. Higgitt originates and terminates as 3-level code whether it is transmitted as Higgitt over radio or as recorder over cables. It is therefore a versatile code for a cable-radio system.

5-Unit Baudot

Five 2-level binaries in time sequence give $2^5 = 32$ possible combinations of signaled characters, which are allocated in various ways in different applications. By means of shift of case, additional characters and mechanical control functions may be included, some being left common to upper and lower cases, and some doing double, noninterfering, duty. Only in its multiplexed time-division applications does Baudot perform its whole function with five units[37]. In the majority of cases it is raised to a 7-unit (Western Union teleprinter), or a 7½-unit (Bell System Teletype) code[38] by the juxtaposition of start and stop (rest) impulses, conveying no intelligence.

Even in its 5-unit multiplex length, this code was too long to be considered for cable use, to replace the 3.7-unit cable recorder. Consideration was given to an old proposal by Cooke for 3-level transmission of a 3-unit code, which would give $3^3 = 27$ combinations. If any were to be set aside for control functions, this short code would force some alphabetic letters into the upper case, and there was a general indisposition to accept the code's limitations.

A more practicable code was devised by Angel[39] in the form of a shortening of Baudot, and it made possible the first successful transatlantic printer operation of nonloaded cables. The marking pulses of the Baudot code were transmitted full length and at their ordinary frequency, but there was an arbitrary reversal of polarity between successive marking pulses. The spacing impulses were transmitted at half-length each, any number of them in succession being joined as to polarity with the marking impulse which preceded them. The uniform length of Baudot, of course, disappeared. This is a most interesting code from the viewpoint of MCT. For one thing, the choice of mark rather than space for full-length transmission takes advantage of the statistical feature of Baudot code of punching the fewest holes (mark) in the tape for characters occurring most frequently. For another, it introduces the idea of the half-bit of information and its transmissibility if joined to make the preceding pulse longer. It does not seem to involve cross-over transients the presence of which would introduce doubts as to its theoretical soundness. The receiving margin, of course, has to be such that signals of length 1.5 pulses can be distinguished from those of unit length. The average length of character was 3.5 pulses—the same as cable recorder code. The system worked but was abandoned in favor of the fill-in system next to be described.

Fill-in Baudot

The code which is used today on Western Union cables starts and ends on terminal landlines as standard Baudot 5-unit multiplex code, transmitted at such a speed (double speed) that single impulses at the receiver do not cross the zero line but merely meet it, and alternations of mark and space are likewise attenuated to about zero level[40]. Such attenuated impulses are overridden, or filled in, by pulses of alternating polarity generated locally at the receiving station through an auxiliary ring on the receiving distributor[41]. Conversely, the full-amplitude double-pulses, triple-pulses, and so forth, are strong enough to take control away from the locally made unit-pulse reversals and to determine the polarity which the first locally generated pulse will have when the cable signal decays.

Since the effect is the doubling of speed without alteration of the 5-unit code as a code, it is somewhat difficult to describe in terms of MCT although of utmost importance to the cable art. In a sense, it adheres to the dictum of not transmitting anything that the receiver can predict—in this instance that upon the decay of a pulse, or of a succession of pulses of the same sign, the next pulse will be of the opposite polarity whether strong enough to affect the receiver or not. In another sense, the transmission has been changed from two quantized levels to three levels *by proxy*—turning into a virtue the inability of the cable beyond to transmit a steep enough wave front to develop fully the single pulses. A third rationalization is to say that within the transmission band of the cable for signals *which it can pass*, the code has been effectively shortened to a little more than 2.5 units per character, or about 1.25 cycles per character[42]. Whatever the rationale, this system has been working well for more than 25 years.

Squier-Bruce a-c Code

In discussing signal wave-front shaping, in the first part of this paper, no mention was made of the equal attention which is given to accomplishing a controlled and rapid decay of each pulse, thus robbing a succession of overlapping signals from evidence of their historicity. (This is MCT in reverse, and suggests that under the new theories a way may be found at the sending end to predict and act in opposition to the receiving end effects). Receiving end shaping concerns itself not only with perfecting the slope of the wave front's arrival, but of minimizing the tailings off, whose additive effects may be traced through a number of succeeding pulses. Cable siphon recorder operators used to *read through* this kind of distorted *handwriting*, but relays, which depend upon definite crossings of zero potentials, cannot so well accommodate themselves. As a result the circuits have had to be slowed down when printers were applied, and the signals shaped.

Several expedients are used to help the electrician shape out signal hold-over. One is "curbing", a scheme[43] incorporated in a recorder code transmitter whereby the cable is earthed momentarily between successive impulses to give the line sig- nals a bias down towards zero. Alter- natively, in multiplex working, each channel is split as to marking and spacing polarities[44], so that when a channel is idle, while 5 spacings will appear in succession they will be transmitted as 2 plus and 3 minus, for example. Finally, there is the common pulsing method of sending two- element signals by discharge of a conden- ser, wherein only the changes of polarity are signaled at the instants of change, with an accelerated decay at the trans- mitting end. Such pulsing might be adap- able to radiotelegraphy.

Squier and Bruce[45] tried out on th Signal Corps' old Alaskan cable a schem of sending three-level sine-wave signals representing dot, dash, and space uni there being an arbitrary reversal of pola ity between units, so that the signal the cable looked like amplitude-wobbl a-c. Great hopes were held out for it, an it may very well be possible that it wou have paid off in increased speed due absence of tailings. However, unli Angel's shortening of Baudot, it seems contain an MCT *faux pas*. In spite of ho innocuous the signal looks, the transmi sion of its intelligence content depen upon successfully dealing with its transients and side-band componen Faithful transmission of various RM potential levels over noise is an MC problem, like diplexing A-M on an F- modulation. Success in obtaining prop shaping at the receiver cannot be assum

6-Unit Baudot

While for most types of work the shi ing of printer case from letters to figu and back is best handled by assignin pair of character combinations to acco plish the shifting and unshifting, sto ticker quotations contain so many tran between upper and lower cases that sh ing is best accomplished by lengthen the code to 6 pulses per character. T presence or absence of pulse numbe determines the case in which the selec type-bar will print.

A 6-unit general purpose printer wo afford 2^6 64 combinations of charac and controls and has been proposed to increase the usefulness of printers in certain language applications. Among other things, it would make possible tabulators and back-spacers. Another proposal which has been tried in the field is to retain the 5-unit code but shift among 3 cases instead of between two.

7-Unit "Error-Detecting" Codes

Noise in radiotelegraphy sometimes reaches levels where $P/N < 1$. A radio operator can call upon the remarkable frequency-amplitude discriminations of the hearing function to "read" mutilated signals by a mental process of integration and exercise of judgment, helped greatly by message context (good MCT). Mechanical receivers, however, print wrong letters when $N > P$. Two forms of 7-unit printer codes are in successful use to combat the condition, both so devised that marking and spacing will bear a 3-to-4 relationship in each character. Upon receipt, this relationship is checked in a monitor circuit, and if fading has added an extra space or if static has added an extra mark, the balance will be upset and the garbled letter will not be printed.

In one form of reception[46], the garbled letter is rectified by exchange of service messages (RQ-BQ) between operators. In the other[47] the rejection of the mutilated character by the pulse monitor will result in temporary seizure of the circuit in both directions to accomplish back-stepping of the transmitting tape for a second try at correct reception, certain 7-unit combinations being reserved for this purpose.

Phillips Code

Before leaving the subject of codes, many of us recall the prevalence of a code used in the days of American Morse on the landlines, known as Phillips, which had to be committed to memory by the operators for the purpose of condensing press dispatches between the "copy" and the key; and re-expanding them upon receipt, between the sounder and the typewriter. Oliver has suggested that anybody can read through omitted vowels:

> MST PPL HV LTTL DIFFCLT N RDNG THS SNTC.

But the Associated Press used to give its Morse operators a stiffer workout, the symbols:

> T CIC F WAD CKX D CHAD YAP D 70TH YOHA.
> HE HD FAPIB UFP BF T SCOTUS SO TR WS NO ALV UTC.

coming over the wire being required to be typed:

> The Commander-in-Chief of the War Department committed suicide in the Chamber of Deputies yesterday afternoon in the 70th year of his age. He had filed a petition in bankruptcy under false pretenses before the Supreme Court of the United States so there was no alternative, under the circumstances.

In terms of MCT, this is planar prediction folded up like an accordion. By machine, it would take some playing!

Codification for Facsimile

Several million telegrams annually, appearing as typescript written on or gummed down to blanks, are scanned, transmitted, and recorded by facsimile[48], chiefly between main telegraph offices and branch offices or customers in the same city.

Single-spaced elite typewriters space 10 letters to the inch and 6 lines to the inch, so that 60 characters, counting word-spaces, can be crowded into each square inch. Under such conditions—the line/dot structure being 100 x 100, or 10,000 pulses per square inch—pulses per character run $10000/60 = 167$. But since an area of 8 inches by 4 inches has to be scanned, the way telegrams are ordinarily typed, and since they average only 40 words, tariffed and gratis, or $6 \times 40 = 240$ characters per telegram, equivalent to $240/60 = 4$ square inches if set solid, the spectrum space occupied is $(32/4) \times 167 = 1336$ pulses or 668 cycles per character.

In applying facsimile to intercity service, these figures are eloquent in showing both the order of handicap under which facsimile machines would compete with printers, and the two principal causes: (1) nearly seven-eighths of the time being consumed in scanning blank paper; (2) a very high pulse-rate per scanned character. Whether either or both of these inefficiencies can be reduced by MCT remains for the future to disclose. Similarity between facsimile and television is a cause for optimism. The facsimile problem should be the simpler of the two—speeds are slower, and there would be no necessity for tying pick-up speed to reproduction speed. Synchronous drums would no longer be a distinguishing feature of facsimile. Scanning and encoding could take place at electronic speeds; transmission would be leisurely, on a narrower bandwidth than at present. Maybe, as in Angel's variant of Baudot, the white paper could be compressed a hundred to one and tied to the black marks. Perhaps a way might be found to retrieve the information now packed in transmitted but discarded levels of gray above the noise background in black-white facsimile. Several lines of interesting inquiry fan out from where we stand, thanks to MCT.

Acknowledgment

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Biography and picture of **Mr. Coggeshall**, who is now Director of Planning, Internati Communications Department, appeared in Technical Review for January 1951.

A Stabilized Power Supply for Use with Submerged Ocean Cable Repeaters

A. ATHERTON

In recent months thermionic telegraph repeaters have been connected into each of a number of transatlantic submarine cables at points on the edge of the continental shelves and are submerged there under many fathoms of sea water. All electric current to each repeater is fed over the cable conductor itself, from that end toward which the repeater sends the amplified telegraph signals, and returns by an earth path to the source. The joint use of the cable core for telegraph signals and for power supply offers no great technical difficulty. The geographical location of the cables is such, however, that high differences of potential often occur between remote ground connections. The current path to the repeater is therefore subject to fortuitous disturbances which may either increase or decrease the source potential needed to maintain a given current.

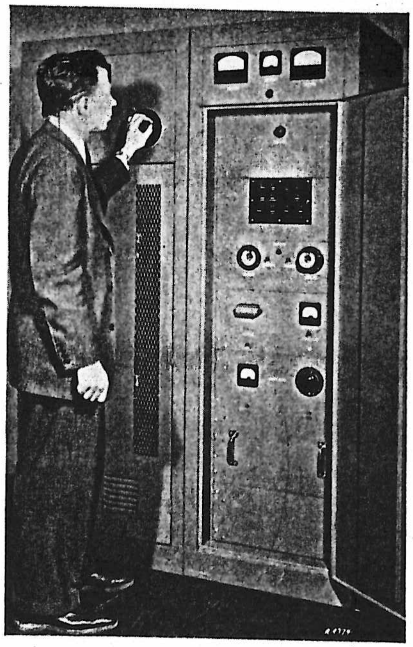
The repeaters themselves require, for faithful operation, an almost perfectly constant current in their circuits. The potential applied to the cable therefore must remain unaffected by any change of voltage of the power available to the station, and at the same time must automatically increase or decrease as earth potentials arise. A special rectifier was found to offer the best solution of the problem. As finally designed, the rectifier and its auxiliary control equipment delivers a current of approximately one-third ampere to the cable with a variation of less than one milliampere throughout wide swings both of primary source voltage and earth current potentials.

General Character of Components

A magnetically-controlled diode operates continually to detect the slightest change of current flowing into the cable core, and provides a correcting signal to the rectifier network. The effect of this signal is amplified to such an extent that full compensation for earth current changes as high as 600 volts is reached with a line current change less than 2 milliamperes.

To prevent ripple and any other transient voltages in the power source from interfering with incoming telegraph signals, the cable termination is made with bridge arms and an artificial line as for duplex telegraph operation with the repeater power entering at the apex of the bridge.

The rectifier itself is a full bridge mercury vapor tube arrangement capable of delivering one ampere of direct current



Power supply unit and cable terminating equipment—Manual adjustment of primary voltage. This is necessary only on initiation of service

DECIMAL POINT AND COMMA PRINTING MECHANISM

Filed Dec. 3, 1949 10 Sheets-Sheet 6

FIG. 6.

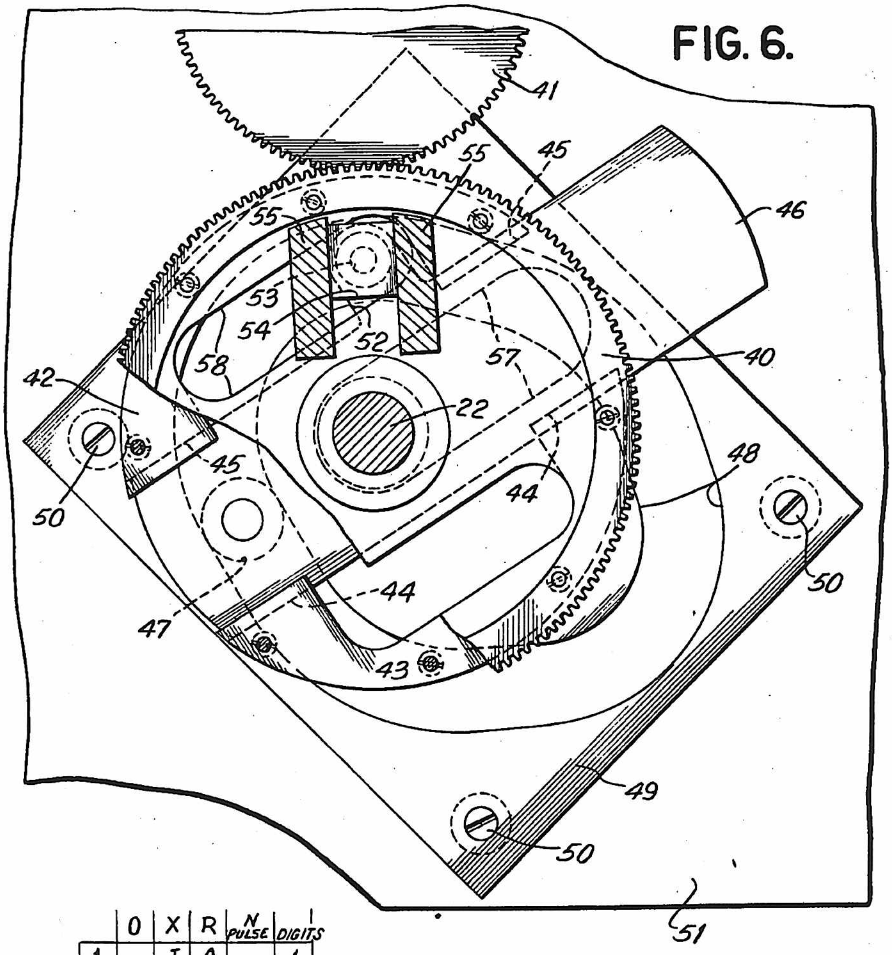


FIG. 7.

	0	X	R	N PULSE	DIGITS
1		J	A		1
2	S	K	B		2
3	T	L	C		3
4	U	M	D		4
5	V	N	E		5
6	W	O	F		6
7	X	P	G		7
8	Y	Q	H		8
9	Z	R	I		9
0	THROUGH ZERO CONTROL				0
8-3	,	#	•	*	
8-4	(	)	·	/	
N PULSE	0	¢	=	$	
184 PULSE			•		
185 PULSE	,				

INVENTORS
H.S BEATTIE
E.J. RABENDA
R.E. PAGE

BY Frank W. Lomnitzer
ATTORNEY

Feb. 10, 1953 E. BUHLER 2,627,807

ROTARY SELECTIVE PRINTER

Filed Dec. 3, 1949 7 Sheets-Sheet 7

FIG. 8.

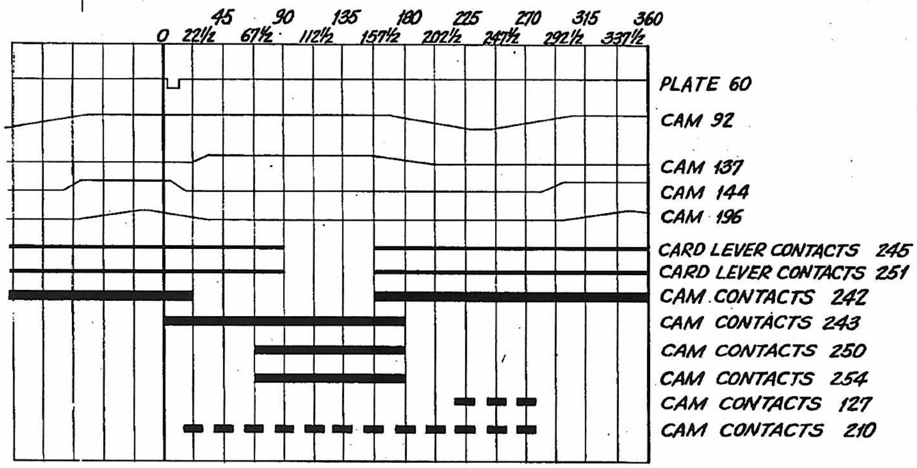
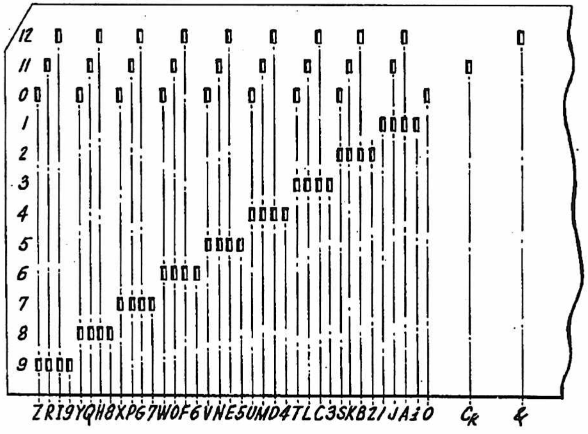


FIG. 9.



INVENTOR
EUGEN BUHLER
BY Ralph C. Dustin
ATTORNEY

June 9, 1953

R. B. JOHNSON

2,641,320

COMPOSITE KEYBOARD

Filed July 13, 1949

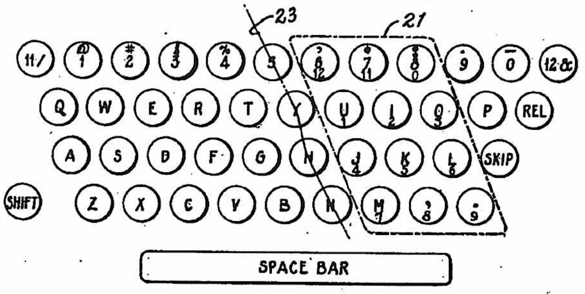
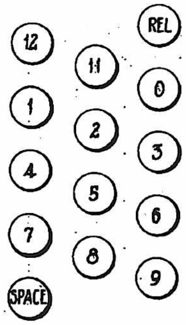


Fig. 1

Fig. 2



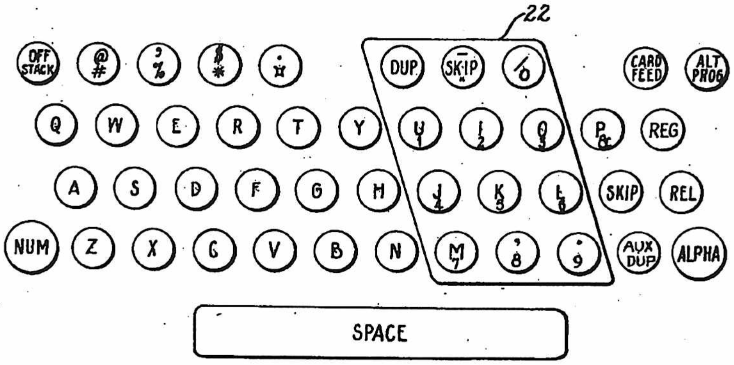


Fig. 3

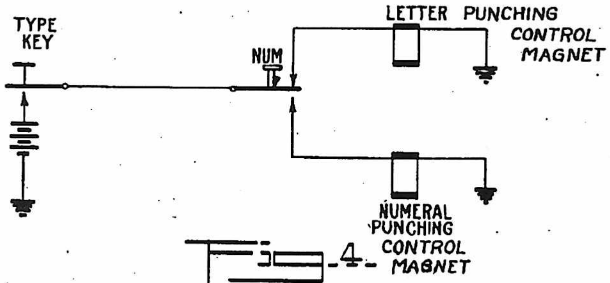

TYPE KEY
NUM
LETTER PUNCHING CONTROL MAGNET
NUMERAL PUNCHING CONTROL MAGNET

Fig. 4

INVENTOR
R. B. JOHNSON

BY J W Armbruster
ATTORNEY

Patented June 9, 1953 **2,641,320**

UNITED STATES PATENT OFFICE

2,641,320

COMPOSITE KEYBOARD

Reynold B. Johnson, Binghamton, N. Y., assignor to International Business Machines Corporation, New York, N. Y., a corporation of New York

Application July 13, 1949, Serial No. 104,462

1 Claim. (Cl. 164—113)

This invention relates generally to improvements in keyboard arrangements, and more particularly the adaptation of a typewriter keyboard for multiple purpose use in controlling both letter and numeral printing or perforating.

It was discovered that the angular relationship between rows and columns of punch control keys on the standard manual keypunch machine used in the Hollerith perforated card system found a counterpart in a group of keys as they appear on the standard typewriter keyboard. The numeral keys of a keypunch keyboard are twelve in number and arranged with four keys in a column, there being three such columns stepped down successively towards the right as they appear to the operator. In other words, the top row of keys is not arrayed in a true horizontal line across the top of the keypunch keyboard; instead the line of keys slants upward towards the left, so also the other three rows in a left to right arrangement of digit keys, slant upward towards the left. The angle made between the vertical and horizontal sets of keys is approximately 70°.

Turning now to the consideration of the appearance of the keys on an ordinary typewriter, it is seen that they are truly horizontal in the rows extending from left to right. However, the vertical arrangement of keys is not truly in a vertical line but does have an angle with respect thereto very close to 70° which is the angle mentioned in connection with the keypunch keyboard. Therefore, it is this discovery and utilization of similarity of key placement which brings about a desired result whereby the touch system acquired by a keypunch operator may be utilized when a section of ordinary typewriter keys are set aside for shift operation to give them the dual purpose of controlling digital keypunching as well as alphabetic print or punch selection. In other words, a group of twelve keys on an ordinary typewriter keyboard are maintained in the usual position and utilized for the usual typewriter character selection operation and then the same group of keys is set aside for shift operation to be utilized with touch control for the control of duodecimal or digital punch selection by a trained keypunch operator. The operator is required merely to shift the angle of operation because, although the angular relationship between the rows and columns of twelve keys is substantially the same on the typewriter, they appear at an angle with respect to the horizontal plane, while on the keypunch machine they appear at an angle with respect to a vertical plane as seen from above.

An object of the invention is to provide keyboard arrangements having a dual purpose for joint touch control operation by those skilled in operating ordinary typewriter keys and ordinary keypunch keys.

Another object of the invention is to set aside a certain group of keys arranged in a standard way on a standard typewriter keyboard and make them available for keypunch control in an arrangement with which an operator is familiar.

Another object of the invention is to vary slightly the arrangement of keys on a typewriter keyboard in order to bring the arrangement of a certain group of keys thereon into a closer resemblance with arrangement of control keys on a keypunch. In an ordinary typewriter keyboard, the vertical array of four keys in a column is not in a straight line but has two jogs in going from top to bottom. For example, although the 5, Y, H and N keys of a typewriter are in substantial alignment, there is a slight degree of divergence in that the Y key is slightly to the right of the center line and the H key is slightly to the left of the center line drawn through the center of the 5 and N keys. Since the keys on a standard keypunch keyboard are arranged in true alignment in columns of four and rows of three, there is a slight deviation from this arrangement when the standard typewriter keyboard is used. Therefore, as an alternative, it is at times desirable to depart from the standard typewriter arrangement and align all vertical and horizontal arrangements of keys and therefore bring the character key arrangement into strict conformity with the group of twelve keys utilized for keypunch control.

Another object of the invention is the provision of a typewriter keyboard with a shift control whereby a certain group of keys thereon is made available for standard digital keypunch control as an alternative to ordinary character selection for typing or alphabet punching control.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated of applying that principle.

In the drawings:

Fig. 1 is a view showing a substantially standard typewriter keyboard as modified here with regard to a section 21 thereon set aside for a keypunch duodecimal control as well as ordinary character selection.

Fig. 2 shows the standard arrangement of the twelve duodecimal and digital control keys of an ordinary keypunch machine as well as the two extra control keys for spacing and releasing a card (see Fig. 1A of Patent 1,976,618, issued October 9, 1934, to F. Lee et al.).

Fig. 3 is a plan view of a typewriter keyboard arranged to conform with the true alignment of the 9 digital keys found in an ordinary keypunch machine. The bordered section **22** is set aside for a keypunch control while these and the other alphabet character keys are in a standard arrangement and available for standard typewriter touch system control for operation of printing and punching.

Fig. 4 is a diagrammatic showing of an electrical shift control wherein the numeral shift key changes the effect of typewriter key operation to change from letter selection to numeral and digital punch control.

In Fig. 1 is shown a standard typewriter key arrangement. There it is seen, as brought out by the broken line **23**, that ordinarily the vertical columns of the typewriter keys are not in true alignment. There is a slight deviation, for example, in going from the 5 to Y to H and to the N keys. However, this deviation is not large enough to alter the mode of touch operation of a skilled keypunch operator accustomed to the keys shown in Fig. 2 when such key controls are assumed to be made coincident with the character keys within the block identified by the border **21** in Fig. 1. There is it seen that the ordinary column of keys representing 6, U, J and M on the typewriter keyboard is also identified as controlling over 12, 1, 4 and 7. Turning to Fig. 2, it is seen that the left column of control keys are also identified as controlling over selection of punching for the numbers 12, 1, 4 and 7. Glancing across the top of the keys in Fig. 2, it is seen that the three top numeral keys are identified as the 12, 11 and 0 keys. These are also found extending across the top of the group of typewriter keys within the frame **21**. There they take the place of, or have additional control over the ordinary typewriter 6, 7 and 8 keys. In the same fashion, the second, third and fourth rows of digit keys are found to be related successively with the typewriter character keys.

In Fig. 1, it will be noted that the arrangement of twelve keys within frame **21** is substantially similar to the arrangement and angular relationships between the numeral keys shown in Fig. 2, the only difference being that the operator must swing to the left and shift in position in order to have the fingers work up and down at the angle found in the ordinary typewriter rather than at the truly vertical line found in the keypunch.

In Fig. 1, it is assumed that the shift key shown at the left operates contacts to control selection for duodecimal or digital keypunching as an alternative to ordinary character printing or punching by the ordinary typewriter key arrangement.

Fig. 3 shows an alternative arrangement wherein the typewriter key arrangement is varied slightly with regard to vertical column alignment in order to conform more closely with the key arrangement found in keypunch machines. There it is seen that, within the frame **22**, the twelve keys are truly aligned in both directions and have an angular arrangement more truly coincident with that of Fig. 2. The nine digital keys within frame **22** are also for dual control and have a selective effect for either character or numeral selection, such characters being of the standard arrangement to which all typewriter touch operators are accustomed. At the left in the bottom row of the key arrangement shown in Fig. 3, is the numeral shift key identified as NUM and this key is used to shift contacts for changing and locking circuit connections for keypunch rather than typewriter key operation.

In Fig. 4 is shown a wiring arrangement for control of letter and numeral magnets or solenoids which can control the printing or punching devices of existing machines in a well-known manner. The key NUM is the numeral shift key which is formed with a "lock down" extension and is held down until released. Key NUM operates a series of contact blades, such as the contact blade shown, to shift control from a normally closed letter selection contact to a normally open numeral selection contact. The "Type Key" of Fig. 4 relates to any of the dual purpose keys within the block **21** of Fig. 1 or the block **22** of Fig. 3. As an example of such a key, the J key of Fig. 3 is normally effective to cause perforation in code or printing under control of the letter magnet for the letter J. However, if the same key is depressed after the NUM shift key is set, it is selective of numeral punch selection for the digit 4 just as controlled by the 4 key of Fig. 2 and its effect over key punching as in the punch of Patent 1,976,618. The letter and numeral magnets can be in the same machine or in separate printing and punching machines.

For cross referencing purposes it may be noted that the mechanism and controls with which the present keyboard arrangements were designed to operate are set forth in the copending application of E. W. Gardinor et al., for a Record Card Punching Machine, Serial No. 103,224, filed on July 6, 1949.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the apparatus illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claim.

What is claimed is:

Typewriter key controls wherein the character selecting keys have the same relative location and general aspect as the keys of a standard typewriter keyboard, but upon which the vertical columns of keys are aligned in straight but slanted lines, the angle which said slanted vertical columns of keys makes with the horizontal rows of keys being 70° and equal to that angular relationship between the columns and rows of digit keys on a standard tabulating card key punch keyboard, a group of twelve of said typewriter character keys being further designated as representative of duodecimal numbers and arranged as shown here under the most effective position of the right hand of the operator,

12
11
1 0
2
4 3
5
7 6
8
9

said twelve keys being provided for dual use for key punch control by the standard key punch touch system as well as by operation in the typewriter touch system, a visually differentiated frame behind said twelve keys to emphasize their dual purpose, a shift key, electrical alphabet recording and numeral key punch control devices operated by said character keys, and electrical means under control of said shift key for selectively connecting said character keys to said key punch number recording control devices for control over electrical key punch operation alternatively with control over alphabetic recording control, whereby a tabulator card punch may be operated in accordance with key punch touch control on typewriter keys.

REYNOLD B. JOHNSON.

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THE POST OFFICE
ELECTRICAL ENGINEERS' JOURNAL

Vol. 46 July 1953 Part 2

The Teleprinter No. 11

C. E. EASTERLING, B.Sc., A.M.I.E.E., and J. H. COLLINS, Graduate I.E.E.†

U.D.C. 621.394.324:621.394.6

This article gives an account of the development, features and use of the Teleprinter No. 11. Amongst other features, this machine incorporates new designs for the keyboard and typehead, an "orientation" facility on the receiving cam unit to facilitate maintenance, and an "end of line" warning mechanism. The Teleprinter No. 11 is replacing the existing Teleprinter No. 3 as the changeover from manual to automatic switching of teleprinter circuits proceeds.

Introduction.

WHEN teleprinter working was introduced into the inland public telegraph service of the British Post Office in 1928, the machine adopted was the Creed Teleprinter No. 3. This was a tape printing machine with a revolving type wheel, the type being inked by means of ink rollers which rub on the faces of the type. The keyboard layout and signalling code were almost identical to that already in use on the Murray Multiplex system; in this there is no separate "space" key, the "space" function being obtained by the depression of the "letter space" or "figure space" keys, and so inversion is always accompanied by spacing of the tape. In addition, as the machine was only intended for tape printing, no provision was made for "carriage return" or "line feed" signals. The keyboard was motor driven, the depression of a key merely serving to trip the transmitting mechanism and determine the 5-unit code combination to be transmitted, the remaining functions of setting up the code and transmitting the signals being carried out automatically. The signalling speed was 49 bauds, i.e., each unit element had a duration of 20·4 mS.

When international agreement was reached on the signalling code and speed for start-stop telegraphy, a code suitable for page printing was adopted, the "letters" and "figures" functions were divorced from the "space" function and the signalling speed was fixed at 50 bauds. By this time however, the Post Office had some two thousand Teleprinters No. 3 in service, and it was decided to retain this machine for use on the inland public network, on which it has continued to give efficient and reliable service.

The Teleprinter No. 7 was introduced in 1932 for use on Telex and private wires. This was basically a page printing machine, although it could be fitted with a tape printing attachment, and conformed to the C.C.I.T. (International Telegraph Consultative Committee) requirements referred to above. Thus, although it could not interwork with the Teleprinter No. 3, it could operate to machines constructed to the same standards by European manufacturers, and private wire and Telex subscriber working to the Continent became possible.

The Teleprinter No. 7 was similar in operation to the Teleprinter No. 3 except for such modifications as were necessary to provide page printing. There were, however, considerable changes in detail to improve reliability and facilitate maintenance. The mechanical design of the machine was based on unit construction principles which facilitated manufacture and assembly and ensured interchangeability of units for maintenance purposes. An ink ribbon replaced the ink rollers, giving cleaner operation and more legible printing.

The Teleprinter No. 7 is still the standard machine which the Post Office supplies to private renters and Telex subscribers, although a number of changes have been, and are still being, introduced to improve its performance. One of the most important of these was the introduction in 1939 of the "striker" transmitter, which ensures much more accurate timing of the output signals than could be obtained with the "link" transmitter which was used on the No. 3 and the earlier No. 7 teleprinters.

The question of reconstructing the public telegraph network on an automatic switching basis was under very active consideration in the years preceding the war and field trial equipment had been designed and tested. At that time it was intended to employ Teleprinters No. 3 as the operating instruments. All work on the project had to be abandoned during the war years, but the matter was immediately reopened on the cessation of hostilities in 1945. In the following year it was decided that the teleprinters to be used on the network should conform to C.C.I.T. standards, so that there would be no restriction on future extension of the system to private or international switching networks. Certain additional features, not available on the Teleprinter No. 3 without extensive modification, were required to enable the machine to operate over an automatically switched system, and it was decided to adopt a new teleprinter which was under development by Creeds at the time, and on which the additional features could be incorporated. This was the Creed Model 47, which became the Post Office Teleprinter No. 11.

The first prototype machine was inspected at various stages of its construction and towards the end of 1947 a sample model became available for tests by the Post Office. This machine did not embody all the features required for automatic switching, but a limited number was purchased and installed on point-to-point circuits so that field experience of the new machine could be obtained at an early stage. These machines were known as the Teleprinter No. 11A.

Meanwhile development of the additional facilities went on, and some 250 machines embodying all the required features were brought into service when the first automatic switching centres were opened at London North and Birmingham in October, 1950. These machines were designated Teleprinters No. 11B. A further 2,000 machines have since been purchased in preparation for the expansion of the automatic switching scheme during 1953-1954.

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† The authors are, respectively, Senior Executive Engineer and Executive Engineer, Telegraph Branch, E.-in-C.'s Office.

During the development of the Teleprinter Automatic Switching System it became apparent that it would be an advantage if the teleprinters installed on the engineering test positions, which were necessarily Teleprinters No. 11B in order to provide the required terminating facilities for automatic speaker circuits, could also inter-operate with Teleprinters No. 7 on private wires which could be routed through the same engineering control board. It was also desired to use Teleprinters No. 11 on the switchboard positions on the Inland and Continental Telex systems, because the visibility of the printing was much better than that of the Teleprinter No. 7 with tape attachment, and to extend their use to the manual switchboards used with various private wire networks. The keyboard layout and signalling code already conformed to that of the Teleprinter No. 7, so that all that was necessary was the addition of an "end of line" mechanism and warning lamp. Machines with this facility are known as Teleprinters No. 11C, and 450 have now been purchased by the Post Office. Fig. 1 shows one of the machines with its cover in position and carrying a message tray with two compartments.

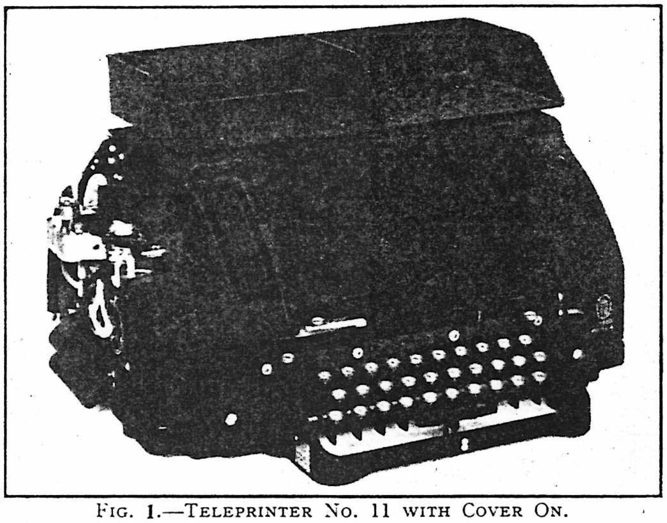

FIG. 1.—TELEPRINTER NO. 11 WITH COVER ON.

General Design Features.

The Teleprinter No. 11 is largely of orthodox design and makes use of many of the mechanisms and principles of operation employed in the Teleprinter No. 7, and in fact a large proportion of the parts are common to the two machines. Fig. 2 indicates the principal units included in the new machine.

The keyboard, described in more detail later, is a departure from previous designs, being of the "saw tooth" type in which the operation of depressing a key, in addition to releasing the transmitting mechanism, positions the combination bars which determine the code to be transmitted. The merit of this arrangement lies largely in the "touch" and in the fact that the keyboard is automatically locked against the depression of a second key without the need for a separate locking bar.

The transmitter is of the "striker" type similar to that used on the Teleprinter No. 7, but with the components rearranged to operate from the saw-tooth keyboard.

On the receiving side some improvements in the design of the electromagnet have been introduced, increasing the stability and facilitating adjustment. The selecting mechanism embodies an orientation device which provides a means of checking and centralising the receiving margin. An improved typehead clutch has also been introduced.

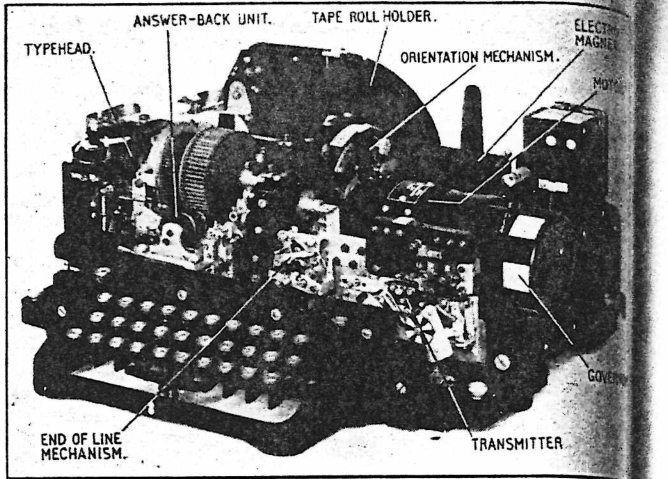

FIG. 2.—FRONT VIEW OF TELEPRINTER NO. 11; COVER REMOVE

Of general interest is the widespread use of new materia
and manufacturing techniques. Great use has been made
zinc alloy (Mazak) die castings for smaller parts. Th
process permits the manufacture of large numbers of par
to extremely close dimensional tolerances. In contrast
the Teleprinter No. 7, ball bearings are used for only four
the main bearings, oil impregnated sintered bronze bush
being used for the remainder and also for many of the mi
pivots.

The Keyboard.

The principle of operation of the saw-tooth keyboard
illustrated in Fig. 3 from which it is seen that a particul
keybar when depressed engages with the sloping edges
triangular projections on each of the five combination
and a trip bar. The combination bars are thus moved to
right or left as required for the particular code sequence to
transmitted, while the trip bar is moved to the left to releas
the transmitter mechanism. The layout of the keys final
adopted conforms to that used on the Teleprinter No.
except that the "WRU" signal, which is the secondary
of letter D, is provided on a separate key, and a shift
bar operated by the "figures" and "letters" keys ensures
the D key cannot be depressed following a figure sh
which, of course, would result in the sending of a WR
signal. This feature, and the placing of the WRU key at
rear out of the normal key field, guards against the accide
sending of a WRU signal and the consequent release of
distant answer-back during operating. Two additional
have, however, been added, namely a "Here is" key and
"Run out" key. The depression of the "Here is" key relea
the answer back unit so that the answer back code ma
transmitted at will to the distant end of the circuit.
"Run out" key provides continuous transmission o
chosen character from the transmitter, the character
corresponding to the last character key depressed. Th
possible because the combination bars on the saw-
keyboard are not restored to one side at the end o
character transmission, as in the motor driven keyb
used by the Post Office on Teleprinters Nos. 3 and 7
remain in the position corresponding to the last cha
sent. The operation of the "Run out" key release
transmitting cam and consequently causes the contin
transmission of this character until the key is release

The keyboard used by the Post Office employs three
of keys, and each key, with a few exceptions, is us
transmit two characters, the primary being a letter an
secondary a figure, punctuation sign, etc. The cha
case at the receiving machine is controlled by the ope
of the "letters" or "figures" key, and failure to pe

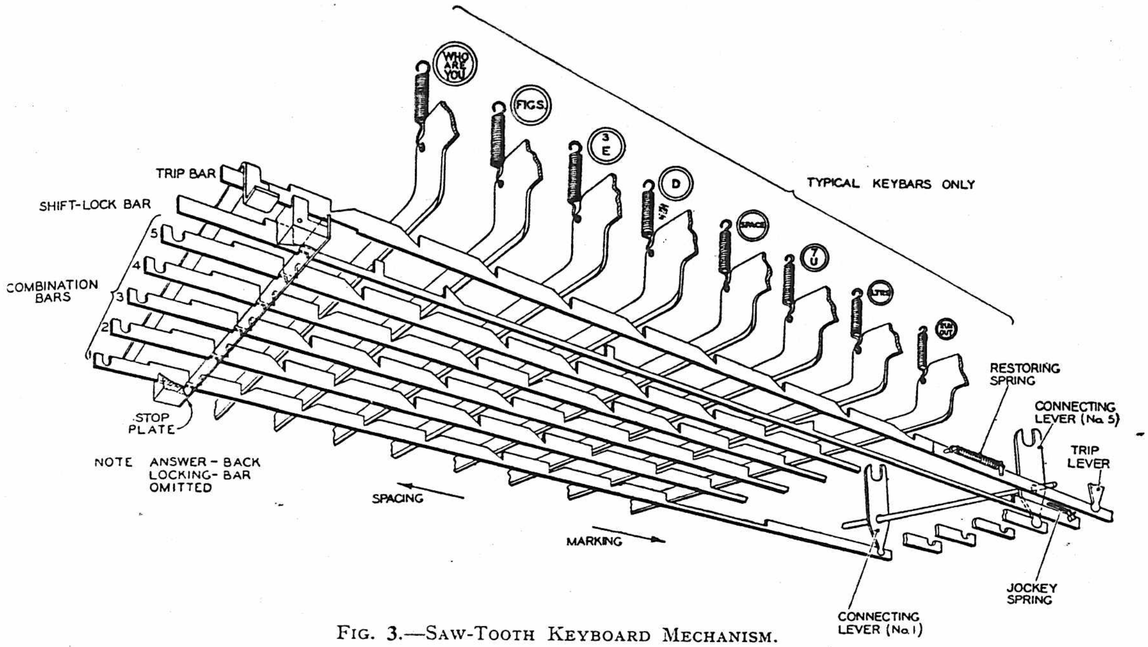

Fig. 3.—Saw-Tooth Keyboard Mechanism.

this operation will result in incorrect reception. It may be of interest to mention that a keyboard has been designed by Creeds which eliminates this cause of error but at the expense of an increase in size and complexity. In this keyboard, which uses four rows of keys, the first three rows are used for letters only, the keys in the fourth row being used for figures in the primary condition and punctuation signs, etc., in the secondary condition. When the "letters" key is depressed the keys in the fourth row are locked against operation, and when the "figures" key is depressed the keys in the first three rows are locked. In order to transmit the secondary character of a key in the fourth row a separate manual shift key must be held depressed.

Another interesting variant of the saw-tooth keyboard, which may also be fitted to the Teleprinter No. 11, has been produced by Creeds, principally for alphabets with more than 26 letters. When such alphabets are employed with the standard start-stop 5-unit code, it is necessary to place one or more letters in the "figures" case. To avoid the necessity of memorising these letters, a specially designed transmitter can be supplied which automatically inserts the correct case-shift signals whenever the operator changes case.

The Orientation Facility.

An innovation of importance from the maintenance aspect is the provision of an orientation facility on the receiving cam unit. The actual cam is made identical, as regards cam tracks and period of revolution (130 mS), with that of the Teleprinter No. 7 but the rest position as determined by the retention pawl is advanced approximately 22 mS. A mechanical delay system (see Fig. **4**) incorporating a clutch-driven cam and giving a delay adjustable between about 12-32 mS is introduced between the electromagnet armature and the receiving cam pawl abutment. With the delay mechanism in its mean position the receiving cam therefore starts to rotate some 22 mS after the commencement of the start signal and comes to rest again 130 mS later. This, of course, does not interfere with the normal start-stop operation of the teleprinter. The orientation device enables the selection periods of the receiving cam to be centralised with respect to the five code elements of the incoming signal so that the teleprinter can be adjusted to the optimum state for receiving signals over a particular line. In a switched system, in which a machine must receive signals equally well over any circuit, the use of the facility is of limited value but by connecting the teleprinter "in local" an approximate check of receiving margin can be made. On previous teleprinters there had been no ready means of checking margin in the field and the advantage of providing a margin testing feature for maintenance and also the desire to assist the manufacturers in standardising their production led to the adoption of the facility.

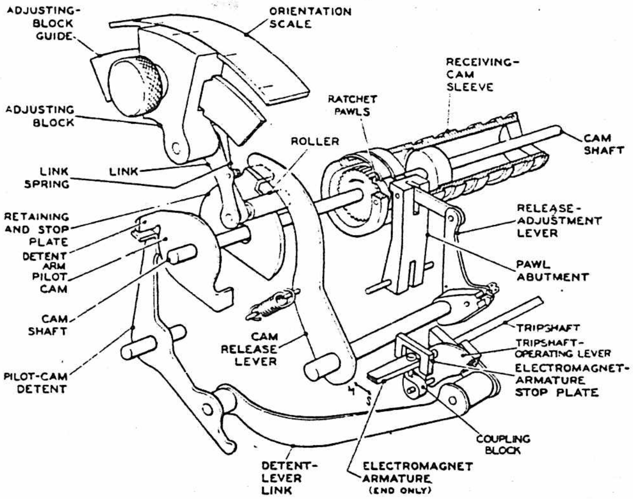

Fig. 4.—Orientation Mechanism.

The Typehead.

The typehead of the Teleprinter No. 11 is a complete departure from previous design. The construction of the driving clutch and the latch mechanism is shown in the assembled and exploded views given in Figs. **5** and **6**. The stop arm and the latch arm are assembled scissor fashion on the typehead spindle together with oilite friction washers, the whole being sandwiched together by the stout axial compression spring. Two shock absorbing springs are inserted between the cups mounted in the two arms. When released the typehead is driven by a clutch of the conventional drum type which slips when the typehead is latched to

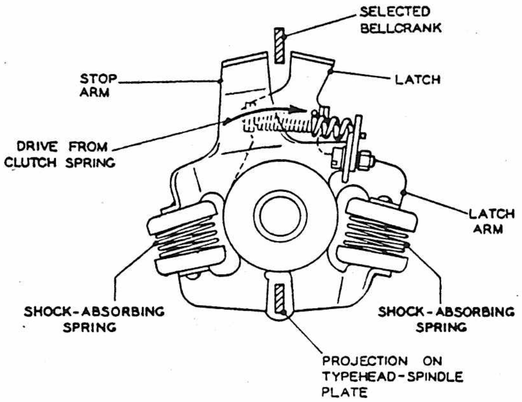

Fig. 5.—The Typehead; Assembled.

a "fallen" bellcrank. In the latched position the bellcrank is gripped between the stop face of the stop arm and the latch on the latch arm while the rear ends of the two arms grip a projection on the typehead spindle and thus locate the type racks. The initial shock of the impact between the stop arm and the "fallen" bellcrank is absorbed by the two shock absorbing springs. After impact the two arms make two or three oscillations about their common axis before coming to rest gripping the bellcranks, during which interval the energy of rotation temporarily stored in the shock absorbing springs is dissipated in overcoming the mutual friction developed by the compression spring. In order to allow time for these oscillations to be damped, the speed of rotation of the typehead shaft has been made greater than on the Teleprinters No. 3 or 7.

The performance of the new typehead clutch has been very satisfactory, the fault rate being about one eighth of that of the clutch previously used on the Teleprinter No. 7. As a matter of interest it may be mentioned that Teleprinters No. 7 are now fitted with a similar clutch.

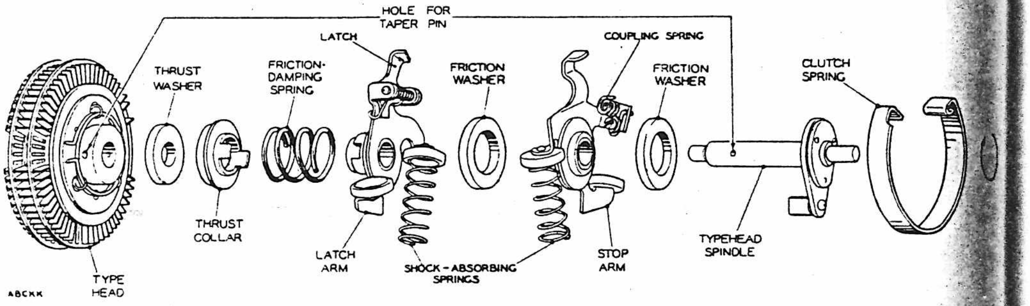

Fig. 6.—Exploded Sketch of Typehead.

Tape Feed Mechanism.

Experience with the Teleprinter No. 3 had shown that some changes in the tape feeding mechanism were desirable. In the Teleprinter No. 3 the roll of tape is housed inside the cover and the heat generated by the motor frequently causes cockling of the paper with a consequent liability for turns to come off the roll and become jammed in the tape roll holder. The tape roll holder of the Teleprinter No. 11 has, therefore, been mounted outside the cover; this has the additional advantage that a new roll of tape can be fitted without removing the teleprinter cover.

The inking of the types is effected by means of an ink ribbon, in place of the ink rollers used on the Teleprinter No. 3, which, although mechanically simpler, are not so satisfactory in use. The whole of the casting on the left-hand side of the machine, which houses the ink ribbon, platen and paper feed mechanism, is hinged at its base so that it may be swung outwards away from the typehead for maintenance operations.

Paper Failure Alarm Mechanism.

In order to effect operating economies it is an advantage to be able to rely on the reception of the answer back at the office of origin at the beginning and end of a transmission as a sufficient acknowledgment of receipt of the message at the office of destination, and thus to dispense with continuous attendance at the receiving machine. Under these conditions failure of the paper to feed correctly could cause message failure and a reliable paper failure alarm is essential. As it was further decided that the operation of the alarm should release the switched connection as an indication to the sending operator, it was also essential that the alarm should not be prone to false operation, otherwise artificial traffic in the form of repeat calls would be created.

In order to appreciate the problem fully it is necessary to define the fault conditions to which the alarm mechanism must respond. These are (*a*) breakage of the tape, (*b*) jamming of the tape not followed by breakage, (*c*) failure to feed the tape sufficiently so that overprinting of successive characters occurs. The device incorporated by Creeds in their original Model 47 prototype was designed with these requirements in mind but subsequent tests showed that it was liable to false operation either during or following manual feeding of the tape, whether by turning the tape feed knob or pulling the tape from the machine. Since a manual feed operation is the normal procedure in order to get the end of a message out, it followed that the first paper feed movement of the subsequent message was likely to be defective and the alarm operated. Another factor which contributed, to indeterminate operation of the paper failure alarm was the presence of slack tape between the tape roll holder and the alarm mechanism. This was overcome by redesigning the roll holder with a simple brake mechanism controlled by the tape tension which may be seen in the top right-hand corner of Fig. 7.

The elements of the alarm mechanism finally adopted are shown in Fig. 8. The tape is taken off the roll holder on the left (not shown) and is moved to the right by the tape feed

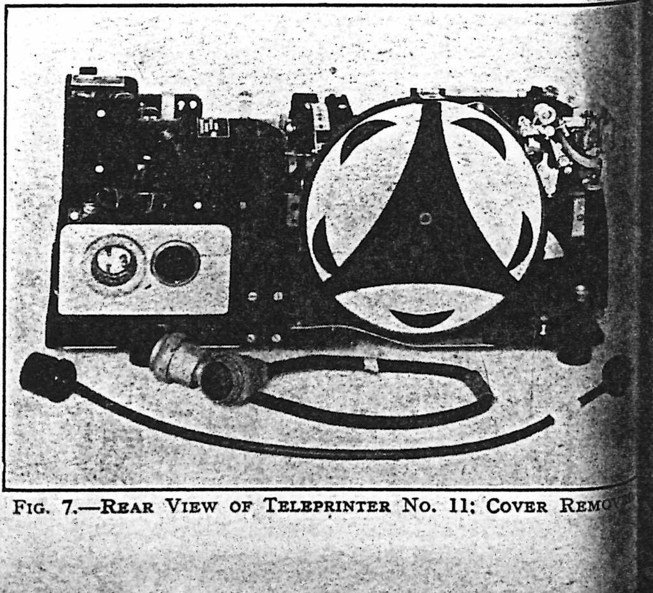

Fig. 7.—Rear View of Teleprinter No. 11: Cover Remo

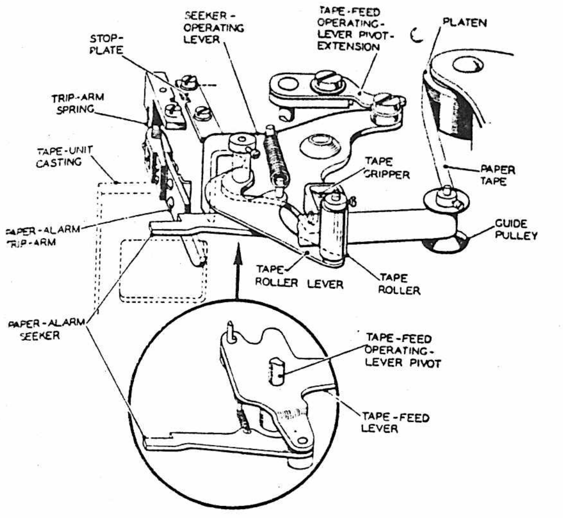

FIG. 8.—PAPER-FAILURE ALARM MECHANISM.

mechanism. The tape is lightly gripped, over its full width, by the spring-loaded jaws of a tape gripper mounted on a pivoted member known as the seeker operating lever. This lever is reset to the left-hand position against a stop plate at the end of each tape feeding operation and is moved by the tape during the subsequent tape feed, the movement being proportional to the tape feed. A projection on the seeker operating lever bears against the paper alarm seeker moving it forward. Simultaneously the seeker is withdrawn to the right during the forward movement of the tape feed ratchet pawl and is moved back to the left during the return motion. If the step at the end of the seeker has not moved sufficiently forward to clear the shoulder on the paper alarm trip arm the latter is displaced and in turn releases a spring-loaded contact operating lever. The forward movement of the seeker is determined by the actual movement of the tape and the design and the adjustments are such that the alarm contacts are operated when the paper movement is somewhat less than half of normal. This degree of overprinting may be tolerated as it represents the condition in which adjacent characters just touch. It should be mentioned that the tape feed ratchet pawl is adjusted so that in the normal rest position there is a lost motion equal to half a tooth pitch. This ensures that however the pawl may be left relative to the ratchet (e.g., by manual operation of the feed knob) the resultant feed cannot be less than one half normal unless a genuine paper fault condition exists.

When a paper alarm condition is set up it is cleared automatically, as far as the machine is concerned, when the next normal tape feed occurs although it is maintained by the position equipment until attended to and a reset key operated. This eliminates the need for any manual alarm resetting facility on the teleprinter itself.

The Motor.

In the automatic switching system as developed by the Post Office, the teleprinter is switched on at the beginning of each call and switched off at the end. In addition, the transmission of the answer back from the receiving machine at the beginning of a call is initiated automatically. It is therefore necessary for the machine to reach its full operating speed in a very short time, and the design features of the scheme imposed an upper limit of one second for a machine to reach its governed speed.

After a considerable amount of work had been done on the measurement of motor starting times and investigation of the possible causes of slow starting it was decided to redesign the motor windings, taking full advantage of the motor frame size to obtain a higher starting torque. The result was a more powerful motor which met the starting time requirement but, as experience has now shown, at the expense of some reduction in brush life. Further investigations are now being carried out to attempt to effect an improvement and some promising results have been obtained using brushes of a different grade of carbon.

The motor used by the British Post Office is a two-range D.C. motor wound for 160V and 200-250V. Motors for other voltages, both A.C. and D.C., are available, though they would not necessarily meet the requirement for a starting time of one second.

Check of Motor Speed.

The means available for measuring teleprinter speed had long been considered in need of improvement, and the introduction of a new teleprinter afforded the opportunity for adopting new methods. It was ultimately decided to provide a twofold check of speed, firstly by a speed test circuit in the switching centre transmitting reversals at a definite frequency, access to which could be obtained by dialling a specified number* and secondly by a tuning-fork-type stroboscope. The first was intended for routine checking of speed and accurate final adjustment of the governor; the second for use by a mechanic while adjusting a governor, to avoid holding the speed test circuit for an excessive period, and also for use where there was no access to the speed test number. Fundamental considerations led to different frequencies being chosen for the two methods, the band width of V.F. channels limiting the frequency of the speed test signal, and size and cost precluding a tuning fork of too low a frequency. Frequencies of 20 c/s and 150 c/s, respectively, were eventually chosen as most suitable from a variety of points of view including the available shaft speeds on the teleprinter, technical considerations in the production of tuning forks and the generation of signals by the signal generators at a switching centre. Two sets of stroboscopic markings were therefore provided on the teleprinter; six segment markings on the governor cover for use with the tuning fork and a six segment disc on the transmitter shaft for use with the speed test number. The latter can readily be made to revolve continuously by depressing the run-out key.

Connecting Cords.

The long cords generally fitted to teleprinters are inconvenient when the machine has to be moved or packed for transport. It was therefore decided that on Teleprinters No. 11 supplied to the Post Office the power and signalling connections should terminate on shrouded pin jacks on the machine and double-ended cords would be used for making the connection to the position equipment (see Fig. 7). These cords remain on the position when the machine is removed.

"End of Line" Indicator.

An end of line mechanism and warning lamp were already available on Creed's standard machine. This indicator was therefore adopted after test, and its basic elements are illustrated in Fig. 9; machines thus fitted are designated "Teleprinter No. 11C".

The mechanism counts each character transmitted, including the non-feed characters, lights a lamp after 55 characters have been sent and restores when the carriage return key is depressed. The end of line counter parts are mounted on the same base plate as the transmitter. A cam track on the transmitter moves link AR (Fig. 9(*a*)) to the right once per revolution of the transmitter and in doing so causes a feed pawl, FP, to rotate ratchet wheel R one tooth.

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* *P.O.E.E.J.*, Vol. 44, p. 107.

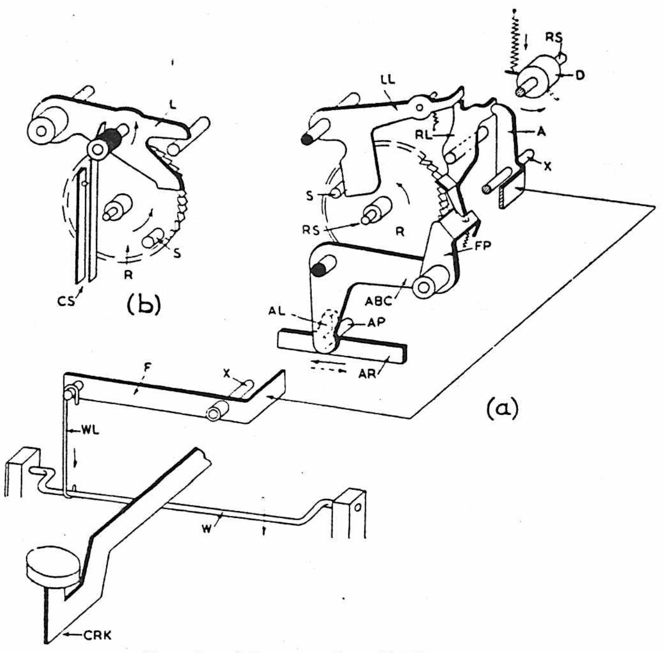

FIG. 9.—"END OF LINE" MECHANISM.

A retaining pawl, RL, prevents backward movement. As the ratchet wheel rotates a spring is elongated and partially wrapped round a drum, D. After 53 teeth have been fed stud S (Fig. 9(*b*)) touches contact operating lever L, and after 55 teeth the contacts CS are fully operated. The periphery of the ratchet wheel is left blank after 55 teeth to prevent further rotation. When the carriage return key, CRK, is depressed (which of course may occur at any time) the cranked trip rod W is rotated and in turn causes the operation of the resetting lever (F and A). This in turn displaces RL which is held out by a latch, LL. The ratchet wheel is thus free to restore under the tension of the spring, and the lamp contacts are opened. At the end of the movement of the ratchet wheel, S strikes LL and releases RL. A damping buffer (not shown) is provided to absorb the shock of the return motion.

The end of line indicator lamp is mounted on a bracket above the governor and shines through a red faceted glass window in the front of the cover. It is sufficiently bright to attract the attention of the operator under the worst room lighting conditions. The choice of a suitable lamp caused some difficulty due to destruction of the filament by vibration and it was early found that a 160 V lamp had an exceedingly short life. Eventually a 6V, 0·3A filament lamp was selected as being the only standard item suitable.

Further Developments.

It will be appreciated that in a machine of the complexity of a teleprinter continual development work is proceeding to improve performance, facilitate maintenance and simplify manufacture. Such changes are introduced as soon as possible on new machines during manufacture, and may be applied to old machines during normal maintenance visits or overhaul if the cost is considered to be justified.

As already mentioned many parts are identical with Teleprinter No. 7 parts and some of the development work has been on parts common to both machines. A friction clamped speed adjusting screw, for example, has been introduced on the governor, with an access hole in the governor cover to facilitate maintenance. A more recent innovation has been the redesigned electromagnet unit the main features of which are the hardened steel stops on the armature, a stop plate rigidly mounted on the unit casting, oil impregnated bearings for the armature, a means of adjusting the polarising flux and the addition of a cover.

A further change, approved but not yet implemented, concerns the paper failure alarm parts which, as can be seen in Fig. 1, overhang the left-hand side of the machine. This arrangement is somewhat unsightly and there is a certain risk of damage during handling. By careful redesign Creeds have been able to produce a more compact mechanism.

An important point on which development effort is now being concentrated is the abatement of noise. Although the Teleprinter No. 11 is not appreciably noisier than many other machines in the same class, the modern tendency is to demand a lower noise level in offices than has been accepted in the past. This is particularly important where the teleprinters are installed adjacent to phonogram positions. The problem has been tackled by the Post Office and Creeds with the object of reducing the noise at source, but although this focused attention, for example, on the advantage of obtaining a greater accuracy in the cutting of gears than had been required in the past, the best results have so far been obtained by standing the machine on a felt pad and lining the dust cover with hessian to damp its vibrations. Further development is now proceeding towards enclosing the machine completely in a new type of dust cover. The machine is resiliently mounted on a rigid sub-base on which the cover is also resiliently mounted, and the vibration of the machine is thus insulated both from the cover and from the table. Promising results have been obtained with the first sample, which possesses good sound reducing qualities, but adds little to the overall dimensions or weight of the machine as compared with the present cover.

Conclusion.

The 250 Teleprinters No. 11B referred to in the introduction have now been in use for over two years. They have given very satisfactory service and show a fault liability somewhat lower than that of Teleprinters No. 7. As a result of experience on these machines and also on the Teleprinters No. 11A some modifications to design have been made on those parts which produced the larger proportion of the faults, and it is expected that machines from later production will show an improved performance.

Book Review

"Power Cables: Their Design and Installation." C. C. Barnes, A.M.I.E.E., A.I.I.A. Chapman & Hall. 272 pp. 68 ill. 35s.

This is the fourteenth volume of a series of monographs on electrical engineering.

It is a businesslike book of 272 pages and there are nearly 70 tables giving an impressive amount of technical detail of power cables. Much of the mathematics has been reserved to appendices and a good balance between theory and practice has been maintained. The book is very readable. There is a bibliography of 111 references. The chapter headings include:—Design Requirements, Core Identification and Assembly, Mechanical Protection, Power Cable Testing Requirements, Calculation of Permissible Current Rating, Intermi Rating, The Effect of Short Time Peak Loads and Sh Circuits on Cables already Loaded, Oil-filled and Gas Pres Super-Voltage Cables, Overseas Super-Voltage Cable Devel ment, Power Cable Manufacture, Installation, Effects Grouping, Jointing and Terminating, Cable Faults, Mod Submarine Power Cables, High Voltage Direct Cu Transmission, Care and Maintenance.

As so many people find that "one look is worth a thou words" it is to be regretted that most of the photog illustrations are too reminiscent in size and quality of the cigarette pictures; otherwise this is a very good book fo engineer concerned with the distribution of electricity.

A. E

Aug. 4, 1953 E. W. GARDINOR ET AL 2,647,581

RECORD CARD PUNCHING MACHINE

Filed July 6, 1949 32 Sheets-Sheet 24

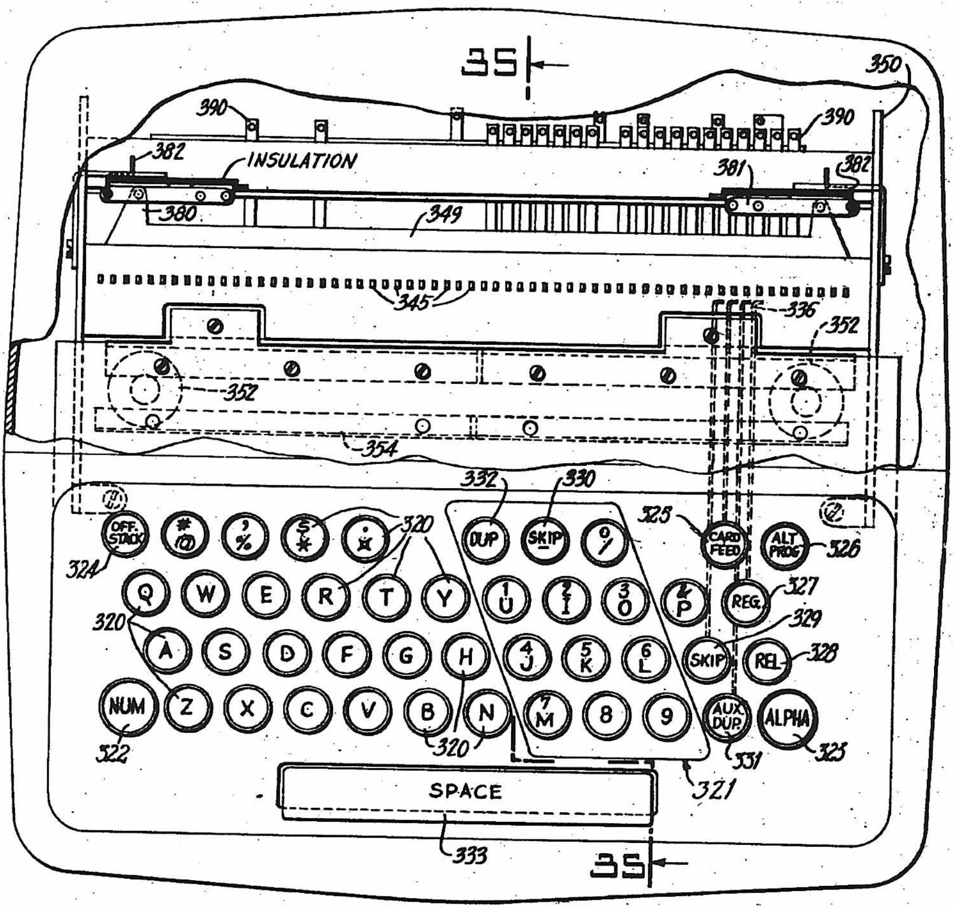

Fig. 32.

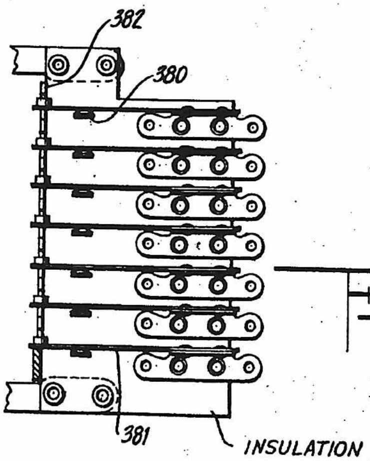

Fig. 33.

INVENTORS
ELLIOTT W. GARDINOR
ARNOLD B. CROWELL
BY William Lang
ATTORNEY

of the d-c machine.[1] It is based on the fact that

$$\text{curl } \mathbf{E}_1 = 0 \qquad (99)$$

which here yields

$$\frac{\partial}{\partial z} E_1^\theta = \frac{2}{D}\frac{\partial}{\partial \theta} E_{1z} \qquad (100)$$

and on the knowledge of the variation of E_1^θ with θ at the boundary $z=0$. This variation is such as to account for the voltage drop between successive conductors, assumed here to be closely spaced, which is also equal to twice the drop along the conductors at corresponding θ, associated with the E_1^z field within them. The factor of two accounts for the conductor 180 degrees away. Thus

$$\left(\frac{\pi D}{Z}\right) E_1^\theta(\theta, 0, \tau) = 2\lambda E_1^z(\theta, \tau) \qquad (101)$$

Noting that E_1^z, and hence $\partial E_1^z/\partial\theta$, are both independent of z, we may write on the basis of equation 100

$$E_1^\theta(\theta, z, \tau) = E_1^\theta(\theta, 0, \tau) + \int_0^z \left(\frac{2}{D}\right)(\partial E_1^z/\partial\theta)dz \qquad (102)$$

$$= E_1^\theta(\theta, 0, \tau) + \left(\frac{2z}{D}\right)(\partial E_1^z/\partial\theta) \qquad (103)$$

Evaluating the foregoing, and using equations 42 and 101, and the definitions of equation 44, equation 43 is readily obtained.

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No Discussion

A Step Forward in Printing Telegraphy

A. S. BENJAMIN
MEMBER AIEE

W. J. ZENNER
NONMEMBER AIEE

Synopsis: Recent commercial and military printing telegraph communication requirements could not be fully met in an efficient and economical manner with existing equipment. This paper describes the objectives being reached in the development of a new integrated line of Teletype apparatus especially designed to adequately serve present and future printing telegraph applications and particularly covers the Teletype Model 28 Direct Keyboard Page Printer Set, Fig. 1. This set consists of a page typing unit, keyboard, electrical service unit, and their motor drive and cabinet housing. The other units which will soon be available are the tape perforator, tape typing unit, and transmitter distributor, which with the keyboard and page typing unit are so designed as to be readily arranged in many combinations to meet specific applications. Fig. 2 indicates the basic units and a few representative combinations.

History of Printing Telegraphy

COMMERCIAL telegrams were transmitted using printing telegraph machines as early as 1851, seven years after the commercial introduction of Morse. Modern printing telegraphy got its start in 1910, with the invention by Howard L. Krum[1] of the start-stop method of synchronization applied to printing telegraphy. Commercial success came in the early twenties, at which time such equipment was primarily used by the commercial telegraph companies and press associations. In 1930 printing telegraph moved rapidly into the business field, and since 1940 we have witnessed the extensive use of that form of communication in military service.

The original applications presented no great problems. Direct circuits were set up between telegraph offices or between press sending stations and receivers located in newspaper offices. Forty-word per minute speeds were considered adequate, messages were printed on plain paper fed from a roll or on individual blanks inserted by operators, and due to the fact that equipment was concentrated in largecenters, only a relatively small number of maintenance men were required.

As the business-field applications grew, the speed went up to 60 words per minute and new requirements were introduced, which resulted in the development of various accessories which were attached to existing units or installed separately. Since the original design of the units did not anticipate many of these functions, the parts for a given mechanism were placed wherever there was space with the result that the equipment was somewhat difficult to maintain. These added features included sprocket feed, horizontal and vertical tabs, motor control, contacts for various switching and control purposes, etc. The space for these mechanisms was limited and it soon became necessary to use external units to provide the multiplicity of control functions.

The 60-word-per-minute speed became too slow for certain applications and the equipment was modified for 75-word operation. Attempts were made to increase the speed to 100 words; however, high maintenance costs severely limited this use. The installation of printing telegraph equipment on ships, planes and

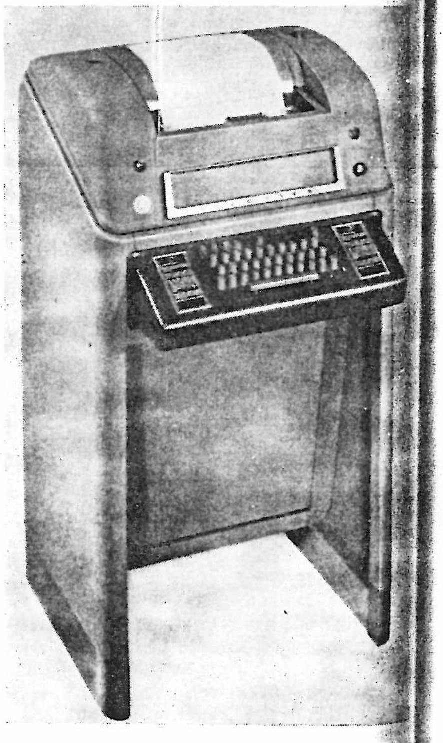

Fig. 1. The model 28 printer set

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A. S. BENJAMIN and W. J. ZENNER are with the Teletype Corporation, Chicago, Ill.

Communication + Electronics #11 March 1954

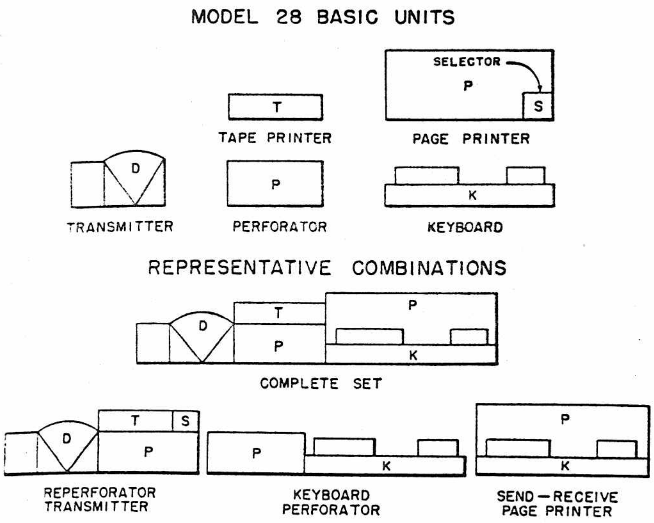


Fig. 2. Model 28 basic units and representative combinations

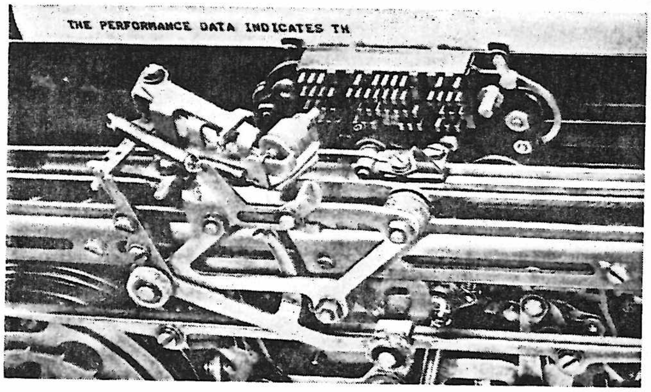


Fig. 4. When the typebox is in the desired position, the printing hammer drives the type pallet against the ribbon and paper

trucks imposed requirements of satisfactory operation at various inclinations and under conditions of great vibration.

As business expanded the use of printing telegraph techniques, the systems became larger and more complicated. Automatic switching was introduced and printers were installed in hundreds of offices of a single user. The Bell System Teletypewriter Exchange Service (TWX) which is similar to telephone exchange service, except that printers are connected through switchboards for typewritten communication, now has more than 35,000 Teletype sets distributed over the entire country. Each of these fields of use required new types of equipment. In almost all cases the equipment was wanted in a hurry, and since the future demand was uncertain, each new piece of equipment was generally provided by modifying an existing machine. This obviously did not result in an orderly development of standardized equipment.

Objectives of New Model 28 Line of Equipment

It became evident that a new line of equipment was needed which would meet the following prime objectives:

1. An integrated group of component units
2. Lower maintenance costs
3. Quieter operation
4. Increased speed.
5. Greater capacity for additional functions
6. Decreased weight

A review of the typing mechanisms used in Teletype units of various kinds and those developed by other printing telegraph producers indicated that they were generally unsuited to meet the new requirements. Typebar carriages were considered too heavy and typewheels difficult to index at high speeds. Existing clutch designs similarly were considered inadequate; felt clutches having always been troublesome due to heat and loss of lubricant and positive clutches subject to breakage due to impact. It was therefore decided to design new elements to specifically meet the requirements of today and the next 10 to 20 years.

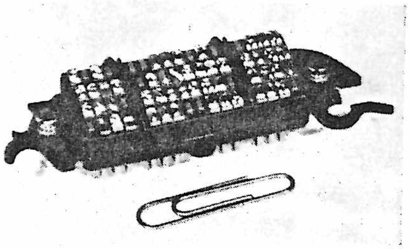
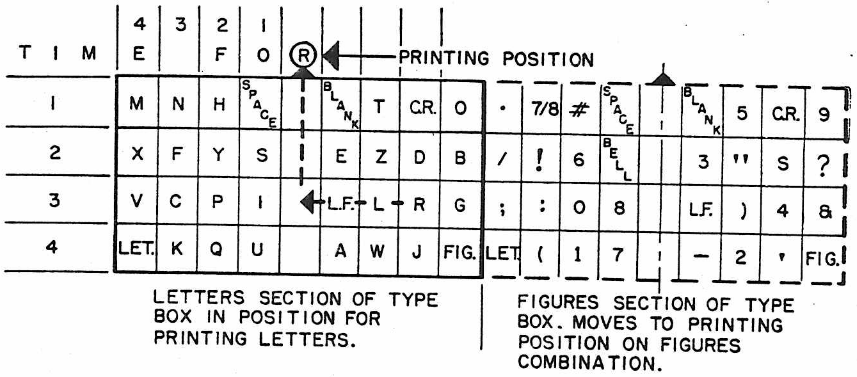


Fig. 3. The typebox, shown in comparison with an ordinary clip

Some of the New Elements of the Model 28 Page Printer Set

The printing mechanism is the most obvious of the several improvments in the new machine. The type pallets, instead of being mounted on bars in the conventional manner are carried in a small rectangular box about 1/2 inch thick, 1 inch wide and 2 inches long, Fig. 3. Sixty-four pallets are arranged in four horizontal rows, each row having a capacity of 16 characters. To type a character, the typebox is moved to bring the desired character to the printing point, and a printing hammer, shown in Fig. 4, operates to drive the type pallets against the typewriter ribbon and paper. Each pallet is provided with a return spring that restores the pallet to its normal position after printing. After the printing hammer has operated, the typebox returns to its initial position below the printed line on the paper, so that the typing becomes visible.

Characters in the left half of the box are letters; those in the right half are figures. A shift mechanism is used to change from letters to figures. The normal position of the typebox for letters



T I M	4 E	3	2 F	1 O	Ⓡ													
1	M	N	H	SPACE		BLANK	T	C.R.	O	·	7/8	#	SPACE		BLANK	5	C.R.	9
2	X	F	Y	S		E	Z	D	B	/	!	6	BELL		3	"	S	?
3	V	C	P	I		L.F.	L	R	G	;	:	0	8		L.F.	)	4	&
4	LET.	K	Q	U		A	W	J	FIG.	LET	(	1	7		–	2	'	FIG.

PRINTING POSITION
LETTERS SECTION OF TYPE BOX IN POSITION FOR PRINTING LETTERS.
FIGURES SECTION OF TYPE BOX. MOVES TO PRINTING POSITION ON FIGURES COMBINATION.

Fig. 5. Typebox arangement and printing method

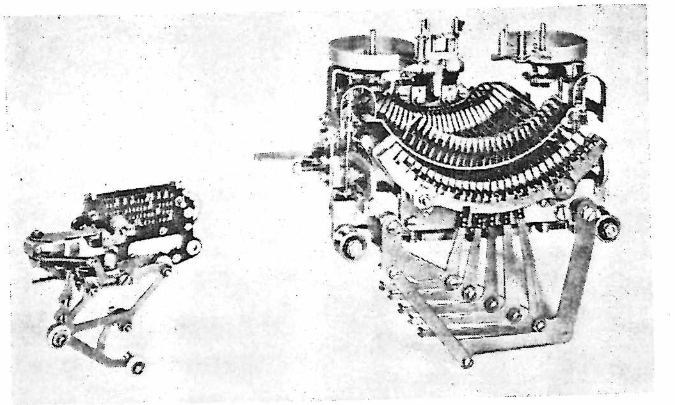


Fig. 6. The new typebox assembly weighs only a tenth of the older moving type basket carriage

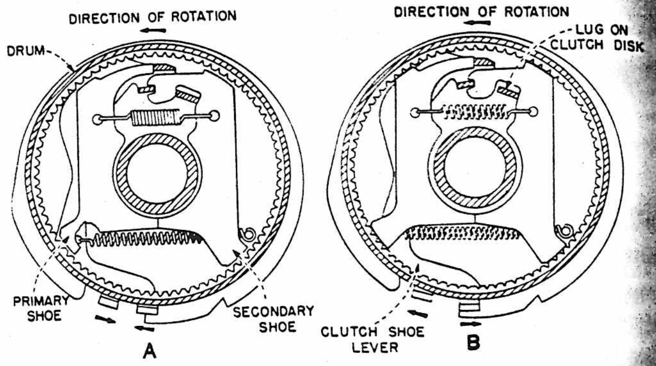


Fig. 7. The clutch is an internal expansion friction clutch

A. Disengaged
B. Engaged

selection is as shown in Fig. 5. When figures are to be printed, the centerline of the figures group is moved to the printing position. Movement of the typebox, in selecting the desired character to be printed, is controlled by two index mechanisms, one controlling the vertical motion to select the proper row of type, and the second controlling the horizontal motion to select the desired character in that row. These motions together form a rectangular co-ordinate system for all the 32 permutations of the standard five unit telegraph code.

The five elements of the code are used to position the pallet in a different manner than on other telegraph apparatus units. The first two elements of the code are used to determine the vertical position of the box; in other words, the nos. 1 and 2 impulses, by their presence or absence in the code permutation, will cause the printer to select one of four levels on the typebox for printing. The no. 3 impulse determines which way the box will move from either the letters or figures centerlines; that is, either to the right or left. The nos. 4 and 5 impulses determine how far the box will move in the selected direction; there are four locations in each. The code combination for *R*, as shown in Fig. 5, causes the box to move upward three levels, then to establish the leftward direction, and finally to move three spaces in that direction, thereby bringing the *R* type pallet in line with the printing hammer.

A unique toggle-type coupling mechanism is provided in the drive system so that the typebox can be stopped in various positions in a gentle manner and without noticeable impact. With this mechanism, the movement of the typebox toward its final position is at high speed, but as the typebox approaches the selected position, the toggle mechanism reduces its speed. At the end of the typebox travel, where further motion is blocked by the index mechanism, the speed of the typebox is about one fifth of that at which it would have passed this position.

Elimination of the conventional type basket greatly reduces the size and weight of the carriage that travels back and forth across the page, starting and stopping for each character printed. A comparison of the old and new type assemblies is illustrated in Fig. 6. In a standard model 15 typing unit, the moving carriage assembly weighs slightly over 5 pounds; the carriage assembly in the model 28 has a total weight of 8 ounces. This 10-to-1 weight reduction results in a very fast carriage return, the carriage returning easily within time of two character intervals (signals received for carriage return and paper feed) at 100 words per minute. Gravity has no significant effect on the carriage motion. The machine can be operated safely on shipboard or in other locations where it might not be in a level position.

Since the pallets are carried in an accurately made box instead of at the ends of the type bars, as in the older machine, type alignment is controlled by manufacture of the parts with no further adjustment required. Stability of alignment, too, is greater, and this should reduce maintenance. This small lightweight carriage also makes possible an over-all reduction in size and weight of the machine, and permits the use of stamped sheet-metal framing instead of the massive cast framework used on the older machines. The weight of the model 28 Teletype printer set is 38 pounds, not including the cabinet and accessories.

At the right end of the typebox, a small manually operated clamping lever holds the box in its supporting carriage. This clamping lever may be released with a light finger motion so that the typebox can be withdrawn from the machine without using tools. Thus the box may easily be cleaned without brushing dirt into the mechanism of the machine. Also, the typebox may be exchanged in a matter of seconds for another having different character faces. On older types of equipment with individual type, it is necessary to solder type pallets to typebars and realign them.

Since each character is separately

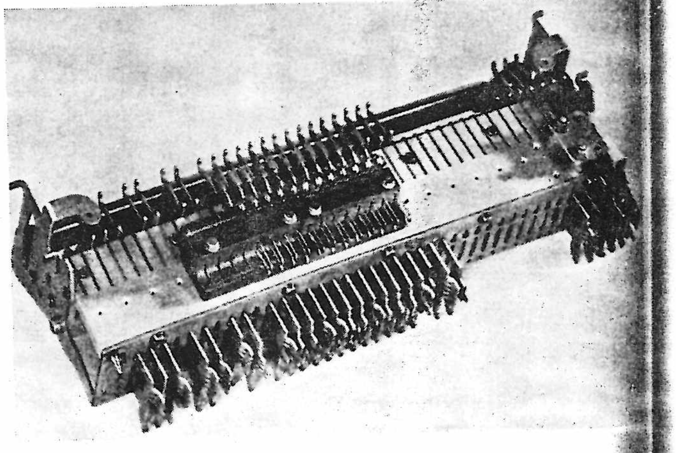


Fig. 8. The stunt box contains code bars for performing nonprinting operations such as line feed, carriage return, shift, etc.

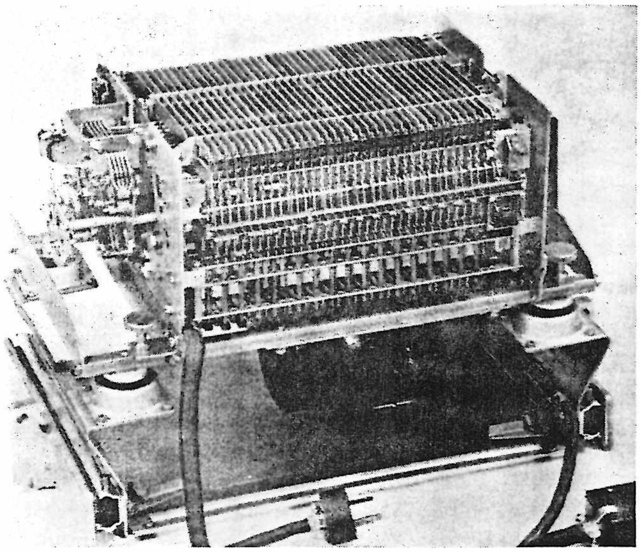


Fig. 9 (left). The sequential selector, which is replaced by the stunt box in the model 28 set

mounted on an individual type pallet, only one operates at a time. In the older machines, with two characters on a single pallet, there is a possibility of printing part of the other character on a pallet if the adjustment is not exact, or if one of the characters is worn, or if several carbon copies are being made so that the surface of the paper is somewhat spongy. The model 28 is capable of making the same number of carbon copies as present machines, and because the same hammer blow is applied for all characters, the printing impression is more uniform than that of a type-bar machine. This characteristic is very important when a large number of copies are being made. The printing blow can readily be increased for multiple copy work by adjusting the tension of a spring by means of a manually operated position lever, Fig. 4. Due to the simplicity of the printing mechanism, it is possible to make the shift from figures to letters and vice versa within the printing mechanism rather than by raising and lowering the platen roller. This simplifies paper handling and improves the readability of the printed record, since the paper remains stationary at all times except during line feed.

The ribbon spools are mounted on the machine itself rather than on the type carriage, thus providing a straight course for the ribbon travel. This not only facilitates changing ribbons, since the path is obvious and the number of guides is a minimum, but in combination with the more gentle blow of the new type hammer, it results in increased life of the ribbon as compared to the older machines.

A newly designed clutch is another machine element that improves operation, reduces maintenance, and contributes to good receiving margins; that is, ability to tolerate distortion of signal pulses. Clutches of the new design are used not only for driving the selector cams, but for the various other power actions, such as moving the typebox, feeding the paper, spacing, etc. This clutch is an all-steel internal-expansion friction clutch, that disengages in the stopped condition, whereas the older clutch depends upon slippage between felt washers and steel plates when a stop is interposed, so that the driven member is mechanically held from turning. Fig. 7 illustrates the method of operation. The continuously rotating driving member is a steel drum, the inner surface of which is grooved, hardened, and ground to give a flat surface on the tops of the grooves. The grooves between the flat surfaces permit wear products to fall away from the working surfaces. Within this drum, two hardened steel members act as drive shoes and are pressed into contact with the rotating drum by a spring-operated pry bar. The leverage system is so designed that through a system of very rigid force-multiplying levers, a small spring produces high normal pressure between the hardened steel friction surfaces. Since the clutch disengages in the idling position, the load on the motor at that time is very small. Life of the clutch equals that of the rest of the machine.

Performance of nonprinting operations, such as line feed, carriage return, and shift, is controlled by a new mechanism contained in a separate subassembly called a *stunt box.* This unit, which is accessible from the rear, extends across the full width of the typing unit, and engages code bars that also extend across the machine. The function bars, Fig. 8, of the stunt box engage notches in the code bars.

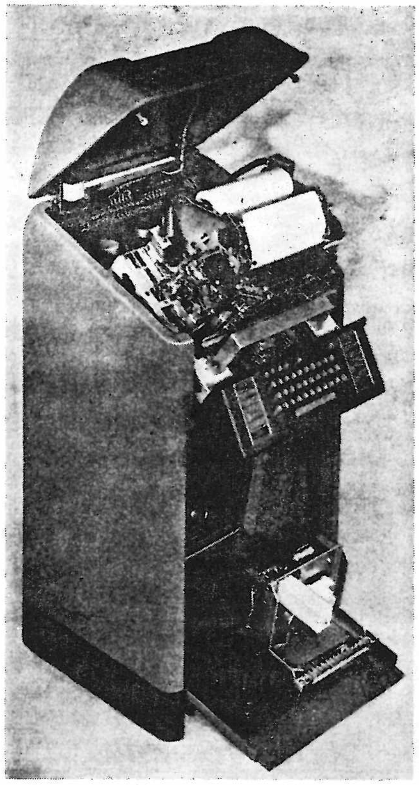


Fig. 10. The equipment is pivotally mounted in the cabinet and swings outward for maintenance. Incoming wires are connected to terminal blocks behind the typing unit

The stunt box has 42 slots, each of which may hold a function bar capable of responding to an assigned code, making it possible to control 42 functions. Approximately 10 are reserved for the common functions, such as line feed, carriage return, and shift, and the remaining 32 are available for special purposes. Stunt boxes are interchangeable. The stunt box may be arranged to perform the functions of the sequential selector unit, shown in Fig. 9, which controls circuits from groups of character combinations sent in a predetermined sequence.

The keyboard mechanism in the model 28 is also different from earlier designs. When the operator depresses a key, a latch is tripped which permits the code bars to move endwise by spring action. In the older machines, depressing a key moved the code bars directly, so that there was considerable variation in the forces required for different code combinations. Thus the new action results in a lighter, shallower, and more uniform key touch.

When the key lever is depressed, one of the bars that moves longitudinally trips the clutch latch and allows the clutch to engage a cam-operated mechanical distributor. This causes the code pattern to be translated into a start-stop

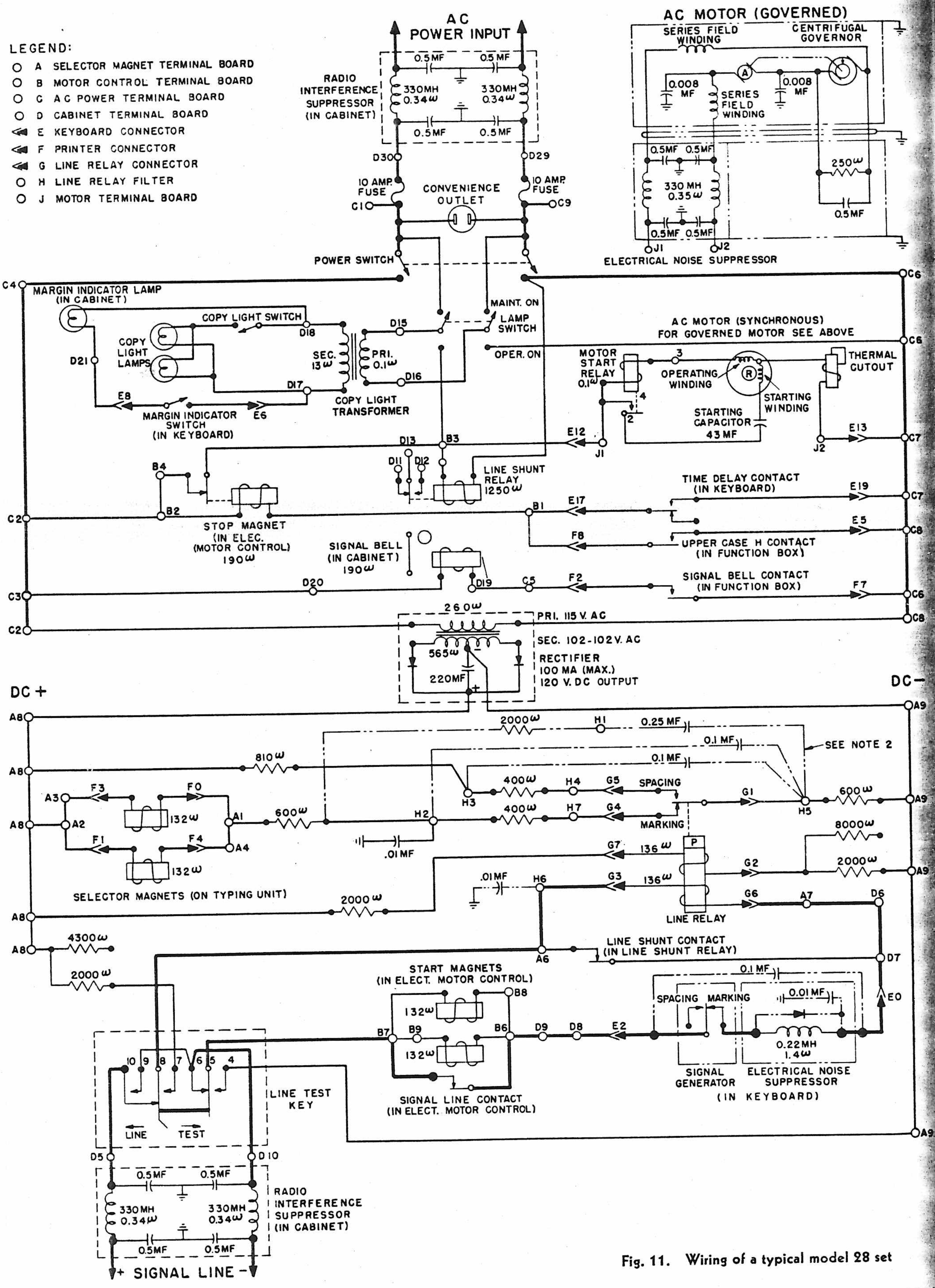
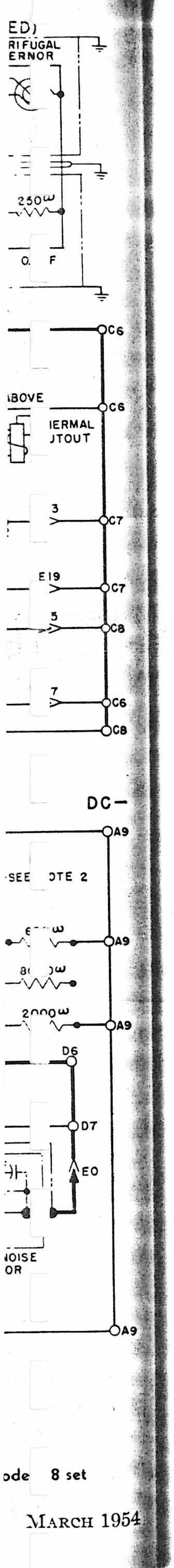


Fig. 11. Wiring of a typical model 28 set



electric signal, the signal itself coming from the signal generator.

The signal generator is a single contact assembly mechanically operated by the distributor. This contact has the form of a transfer switch and therefore permits either open or closed signal transmission or transmission of signals of alternate polarity. The contact is mounted in a metal box for mechanical protection and shielding against radio interference, and requires no adjustment other than in positioning the box itself.

The cabinet for the new machine was designed to suppress machine noise, improve operating convenience, and provide better appearance. The equipment is housed in a new floor model, Fig. 1, with all mechanical controls brought to the front so that the machines can be mounted side by side in rows. Even the manual platen crank has been eliminated and replaced with a rapid motor-driven feedout controlled by a button on the keyboard. A lamp within the cabinet illuminates the copy, and the angle of the window above the copy has been chosen so that glare is practically eliminated. The upper section of the cabinet swings open to provide access for insertion of paper and ribbons and for maintenance. Fig. 10 illustrates how the equipment may be swung upward and forward to give access to both sides and rear of the machine.

Electrical Features and Circuits

Electric accessories such as the line relay, motor control relay, rectifier, fuses, etc., have been placed in a box behind the machine. The interconnections between the several units have been made simple and flexible, which permits installation of a standard machine where circuit termination requirements vary. In the cabinet below the printer there is a shelf on which a front panel is pivotally mounted, as shown in Fig. 10, providing mounting surfaces for auxiliary equipment if this is desired.

The equipment is driven by a synchronous motor when 110-volt regulated alternating current is available, or by a governed motor when unregulated alternating current or direct current is available. Printing telegraph equipment requires speed control of ±1 per cent. The governor used on the model 28, which is of new design will maintain the speed, and once adjusted, it will generally hold speed for the life of the motor brushes, even if the governor contacts wear or pit considerably. The older-type of governor requires frequent readjustment and maintenance and is subject to speed change due to comparatively slight wear or pitting of contacts.

The wiring of the model 28 Teletype set described herein, equipped with the most commonly used electrical features, is shown in Fig. 11.

Conclusion

Since operating experience indicates the model 28 page printer set requires less maintenance than other printing telegraph equipment, it is expected that its field of use will be extended to include more remote locations. The other units of the new line: the tape printer, perforator, and reperforator transmitter, have undergone extensive tests, which indicate they will give the same service as the page printer. These units also have new and novel features and will be available in the near future to serve the needs of printing telegraph users.

Reference

1. **Howard L. Krum.** *United States Patent No. 1,286,351*, 1919.

No Discussion

Torque Requirements of a Radar Antenna

M. MARK
NONMEMBER AIEE

Synopsis: Results of wind tunnel tests on an experimental radar antenna are discussed. The torque required to rotate the antenna was seen to vary with the azimuth position, the elevation angle, the pivot location, the rotating speed, and the wind velocity. A correlation of the data based on dimensionless parameters was found.

A KNOWLEDGE of the loads imposed on a radar antenna at various wind velocities is important in order to obtain the optimum design for the driving and supporting mechanism. The torque loading in azimuth at various rotating speeds and wind velocities is a function of the position of the center of rotation or azimuth pivot location. Therefore, the engineer designing power drives for radar antennas would like to know the optimum position for the azimuth axis and the torque requirements for this pivot position. An experimental radar antenna was installed for testing in a wind tunnel in order to find the azimuth torque loadings associated with various pivot locations, antenna elevation angles, wind velocities, and rotating speeds. This paper discusses the general results of the testing. Elevation angle as used here will refer to the angle the antenna reflector screen makes with the vertical, positive when the concave face of the reflector points up, negative when down or depressed. Azimuth angle will refer to the angle measured in the direction of antenna rotation from the zero position, zero position being with the concave face of the antenna reflector directed into the wind.

Description of Equipment and Tests

The dimensions of the experimental reflector, a single-curvature parabolic type, were 26 by 84 inches. The reflector surface consisted of an aluminum screen, 3/16-inch standard expanded metal. The reflector was mounted on a special plate so that its location, and consequently the location of the pivot in azimuth, could be varied. The plate in turn was mounted on a pedestal incorporating a hydraulic drive, and rotated, turning the reflector. Fig. 1 shows the experimental antenna, installed in the wind tunnel, elevated to 45 degrees. A pressure-sensitive element in the supply line of the hydraulic drive provided a means for measuring

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M. MARK is with the Raytheon Manufacturing Company, Newton, Mass.

IBM

704

electronic data-processing machine

manual of operation

May 1954?

word causes an end-of-record skip, leaving the incomplete word in the MQ. The tape check indicator will not be turned on because an incomplete word has entered the MQ. (*Note:* This will not decrease tape-checking when binary tapes are being read, because detectable incomplete binary words will be detected by the redundancy check.) If a CPY instruction is not given for the incomplete word, the extra characters are automatically brought into the MQ (because word $n + 1$ of a record is always transmitted to the MQ after n CPY's). A tape check occurs only if the computed lateral or longitudinal bits do not compare with those on the tape. Use the delay instruction, WRS 333_8 to delay the execution of any instruction until the MQ is available. After the delay instruction has been given, the store MQ (STQ) instruction may be used to store the contents of the MQ in core storage.

When an incomplete word is brought into the MQ from tape, the unused portion of the MQ contains zeros.

Character Alteration in BCD Mode

Altering characters when reading or writing in the BCD mode on the 704 changes the zones of some of the characters and the numerical code of the character representing zero. The zones differ from the 702 code because the 704 requires this zone change to help fast sorting procedures. Because redundancy checking is an even parity check on peripheral equipment (and in the BCD mode on the 704), the pure zero would not have a non-zero bit. Several pure zeros would correspond to an end-of-record gap. Thus, the zero character is changed to 00 1010 in the BCD mode. The zone alterations follow:

CLASS	IN 704	ON TAPE
Numerical	00	00
A to I	01	11
J to R	10	10
S to Z	11	01

Table III shows the automatic alteration of all characters during transmission in the BCD mode.

CHARACTER	IN STORAGE	ON TAPE
0	00 0000	00 1010
1	00 0001	00 0001
2	00 0010	00 0010
3	00 0011	00 0011
4	00 0100	00 0100
5	00 0101	00 0101
6	00 0110	00 0110
7	00 0111	00 0111
8	00 1000	00 1000
9	00 1001	00 1001
#	00 1011	00 1011
@	00 1100	00 1100
—	10 0000	10 0000
J	10 0001	10 0001
K	10 0010	10 0010
L	10 0011	10 0011
M	10 0100	10 0100
N	10 0101	10 0101
O	10 0110	10 0110
P	10 0111	10 0111
Q	10 1000	10 1000
R	10 1001	10 1001
$\overline{0}$	10 1010	10 1010
$	10 1011	10 1011
*	10 1100	10 1100
&	01 0000	11 0000
A	01 0001	11 0001
B	01 0010	11 0010
C	01 0011	11 0011
D	01 0100	11 0100
E	01 0101	11 0101
F	01 0110	11 0110
G	01 0111	11 0111
H	01 1000	11 1000
I	01 1001	11 1001
$\overset{+}{0}$	01 1010	11 1010
.	01 1011	11 1011
⌑	01 1100	11 1100
Blank	11 0000	01 0000
/	11 0001	01 0001
S	11 0010	01 0010
T	11 0011	01 0011
U	11 0100	01 0100
V	11 0101	01 0101
W	11 0110	01 0110
X	11 0111	01 0111
Y	11 1000	01 1000
Z	11 1001	01 1001
‡	11 1010	01 1010
,	11 1011	01 1011
%	11 1100	01 1100

TABLE III

PERIPHERAL EQUIPMENT

THIS section of the manual describes available peripheral equipment using standard 704 input-output units. Tape units can be connected to card punches, card readers, and printers to provide independent machines that can perform many operations not requiring the logical ability of the 704.

The Type 719 or Type 730 Printer with a Type 760 Printer Control Unit and a Type 727 Tape Unit may be used for peripheral printing. This operation is described in a preliminary edition of the manual of operation for the 719 and 730 printers.

CARD-TO-TAPE CONVERTER

THE TYPE 714 card reader and its Type 759 control unit may be connected by cables to a tape unit to record on magnetic tape data from IBM cards.

By control panel wiring it is possible to transcribe the entire card on tape or to select any combination or arrangement of fields. The sensing of the record storage mark causes an inter-record gap on the tape. Unpunched card columns preceding the record storage mark are written as blank characters on tape. Characters may also be emitted from the control panel or the grouping feature may be used to convert two card records to a single tape record.

Operation

To accomplish a card-to-tape conversion, a tape unit is connected by cable to a card reader and the card reader control unit. The tape is properly loaded in the tape unit and the door is closed. Depressing the tape unit load-rewind key feeds the tape into the vacuum columns to be taken to the load point. Depressing the start key then turns on the ready light.

When the ready status has been established in the tape unit, the card reader may be operated. Place cards in the hopper and press the start key once to run in the cards. A second depression of the start key causes the card-to-tape conversion to begin.

When the end of the tape is reached, the operation stops. Remove the cards from the hopper and press the start key to record the last two cards in the feed on tape. A tape mark is automatically recorded after the last card. Rewind the tape by pressing the load rewind key. Remove the tape from the columns by pressing the unload key and taking off the reel. Repeat the normal starting procedure to resume the operation.

When the end of the card file is reached, end the operation by pressing the start key and recording the last two cards in the feed. A tape mark is automatically recorded after the last record. If desired, an additional file of information can be written by loading additional cards without rewinding the tape.

Recording

All standard punched card characters are recorded on tape as indicated by the character code chart (Figure 44). The following card punches are recorded as indicated:

CARD	TAPE
Zone 11, numerical 0	$\bar{0}$
Zone 12, numerical 0	$\overset{+}{0}$
Zone 0, numerical 2 and 8	Record Mark
Zone 12, numerical 5 and 8	Group Mark

Checking

During a card-to-tape operation, checking consists of the following:

1. The cards are read at two brush stations. At the first brush reading, the number of holes in each horizontal row of the card is determined to be odd or even. This information is stored in twelve binary triggers. The reading of the card at the second set of brushes reads the card into record storage. When data are read out of record storage, the number of holes in each horizontal row of the card is again checked for odd or even number. This number is stored in another set of twelve binary triggers. These two sets of triggers are compared to insure correct card reading.
2. After the card record has been recorded on tape, the tape is backspaced and read for a lateral check for each character and longitudinal row check for each record.

Whenever the control panel is wired to control information going into record storage, it is also necessary to wire it into the check entry.

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GENERAL DESCRIPTION 28D1
ISSUE 1 JUNE, 1954

TELETYPE
PRINTER

Fifty years of leadership in printing telegraphy, packaged in one all-new instrument.

L621.38235
1

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TELETYPE

SYMBOL OF LEADERSHIP IN PRINTING TELEGRAPHY

All New

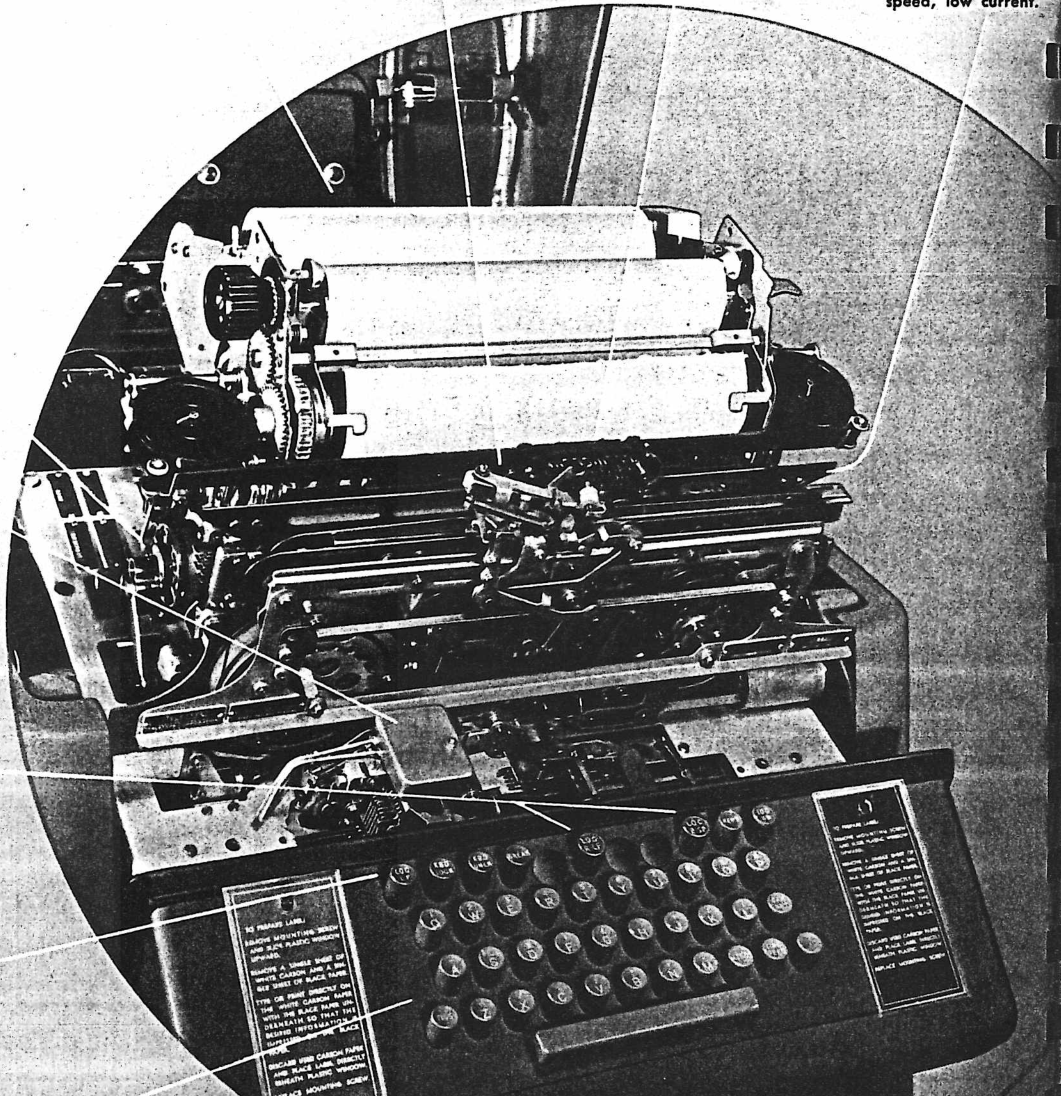
FEATHER WEIGHT CARRIAGE
Dependable carriage return at 100 words per minute—at any angle—with only one carriage return and one line feed signal.

TYPE BOX PRINTING
Type box instantly removable, without tools, for cleaning or changing type.

BUILT-IN STUNT BOX
Revolutionary . . . offers unlimited variety of signaling, switching, and control operations with minimum investment, low maintenance.

SELECTOR
Simple pulling magnet selector . . . hig speed, low current.

ALL METAL CLUTCHES
No idling load . . . require lubrication only once a year.



SIGNAL GENERATOR
Single contact design . . . polar or neutral signals.

DOUBLES AS TYPEWRITER
For the first time a printing telegraph machine can be equipped with back space and reverse line feed.

CONTROLS
All at front, all by keyboard button, for operator's convenience.

POWER KEYBOARD
Light and uniform key touch.

TELETYPE PRINTER

The Teletype 28 is a completely new instrument. It represents a giant stride forward in the printing telegraph art—it is *years* ahead.

Speed is built-in—with harmonic motions...with lightness and simplicity of parts. The Teletype 28 printer actually operates with greater ease at 100 words per minute than conventional machines at slow speeds. However, it will not lose efficiency at lower speed and can be adapted for use with present equipment by a simple gear change.

The printer is small in size, light in weight, and extremely quiet in operation.

Operation is not affected by tilting or severe vibration. Also, the resilient sheet metal construction provides exceptional shock resistance. Thus it will operate reliably in mobile applications.

The Stunt Box expands the printing telegraph alphabet for nontyping tasks of every description...typeboxes are interchangeable...the machine can double as a typewriter where space is limited.

Speed for speed, this printer will cut customary maintenance to *one-fifth.* The metal clutches rarely need oiling, loads are lighter (no load when idling), there is less friction, less heat. New, more efficient motors were developed for the equipment. A new governor holds its speed setting for at least 3,000 hours. Thus operating costs are lowered, and printers can be installed in locations where frequent servicing is not practical.

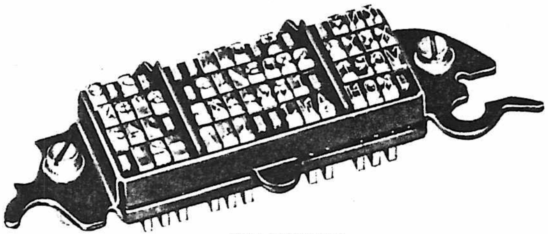
The Teletype 28 Printer ushers in a new line of Teletype equipment—a line engineered to meet today's most complex communication problems, and with built-in facilities to solve new problems as they arise. It is an integrated line, with common mechanisms and parts wherever practicable. For the new elements of the companion units, the same fresh approach has been used as with the printer—design principles were employed with an accent on the future.

The new line embodies the cumulative know-how of the many years of continuous manufacture by the Teletype Corporation, backed by an extensive and unremitting research program conducted with modern industrial research techniques—with a full complement of creative personnel and adequate laboratory and technical facilities.

TELETYPE

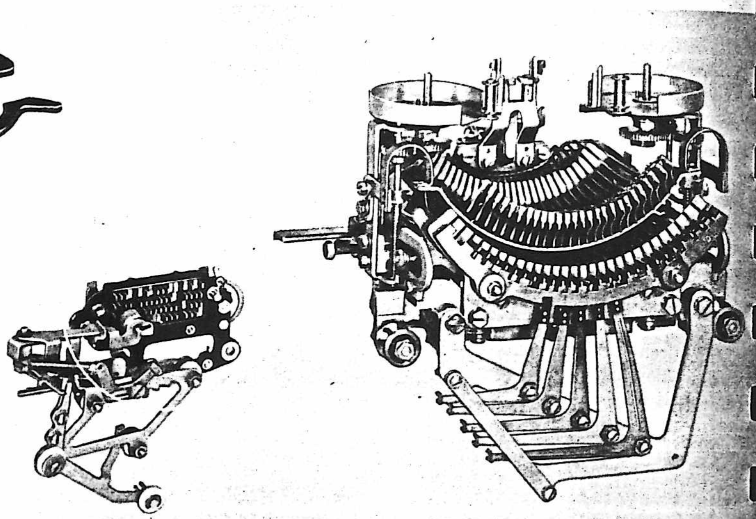
SYMBOL OF
LEADERSHIP
IN PRINTING
TELEGRAPHY

FEATURES OF THE



THE TYPEBOX
Actual Size

How this new printing principle works: (a) the typebox is moved to bring the selected character to the printing position; (b) the print hammer drives the type pallet against the ribbon and paper. After each stroke the typebox is returned to its unoperated position below the printed line. Shift and unshift are governed by typebox position; the platen remains stationary.



SIZE OF CARRIAGE SHOWN IN RELATION TO CONVENTIONAL "BASKET" CARRIAGE. THE NEW ASSEMBLY WEIGHS ONLY 1/10TH AS MUCH.

Featherweight carriage is built for speed. Carriage return is quick, easy, requires no extra signal at 100 words per minute.

Carriage motion is not affected by nonlevel positions, assuring dependable operation on planes, ships, trucks, etc.

The new carriage makes possible a smaller, lighter machine; also permits use of resilient stamped framing instead of castings, further reducing machine size.

Type alignment is built in—eliminates on-the-job aligning.

Typebox is quickly removable, without tools, for cleaning, etc.

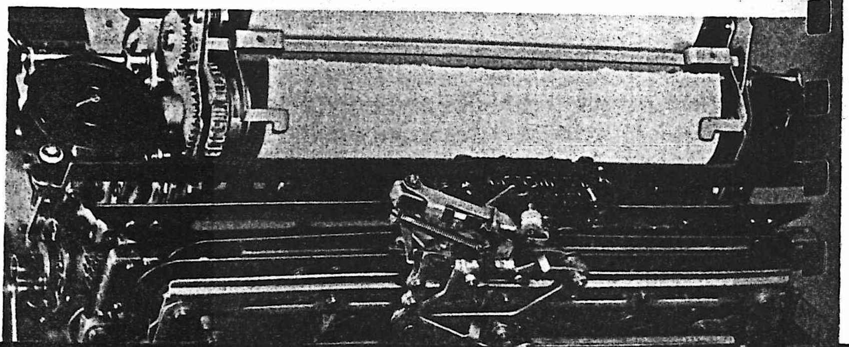
⑥ Typeboxes are interchangeable. Type arrangements can therefore be changed quickly. Gives operating flexibility...facilitates field conversions ...eliminates soldering of type pallets.

⑦ Copy is more uniform because the same print hammer blow is applied to all characters. This is especially important in multiple copy work.

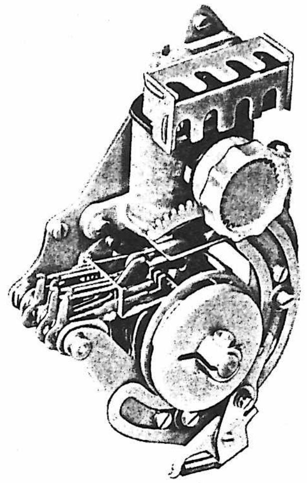
⑧ Overscoring and underscoring are eliminated, since each character is mounted on a separate pallet in the typebox.

STRAIGHT RIBBON TRAVEL

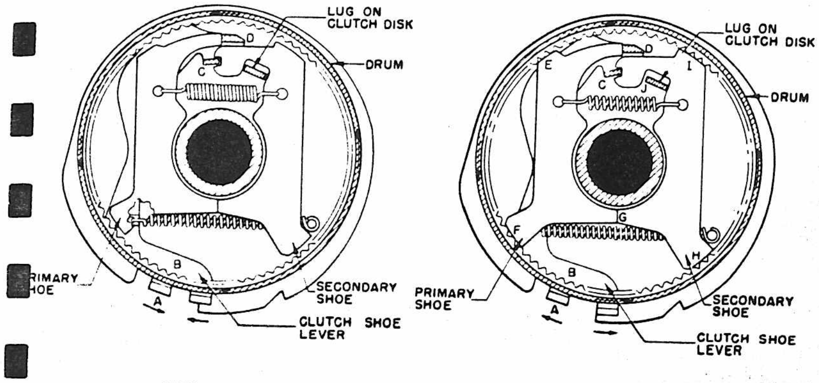
The ribbon spools are mounted at the sides of the machine rather than on the type carriage, providing a straight course for the ribbon travel and reducing the number of guides required. Simplifies ribbon changing, prolongs ribbon life.



THE PRINTER



New high-speed pulling magnet selector... low current operation...few and simple adjustments. Range setting is quickly obtained by means of a self-locking, direct-reading knob. Driven by dependable, low-maintenance metal clutch.



DISENGAGED **ENGAGED**

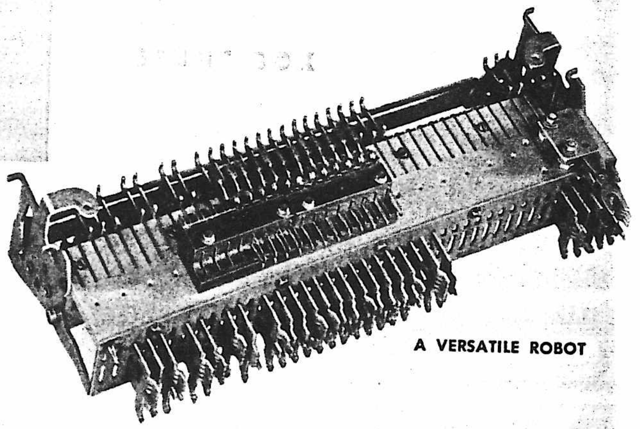
NEW CLUTCH DESIGN USES INTERNAL EXPANSION PRINCIPLE.

Leverage is so arranged that by means of rigid force-multiplying levers a small spring produces pressure so high between steel drive shoes and an enclosing drum that the load is driven without slippage.

The long life clutch operates with exceptional stability and generates high torque capacity capable of handling both positive and negative loads. Its engagement is positive, uniform, and the short engaging time is accurately repeated cycle after cycle.

This advanced clutch design eliminates the wear and constant need for lubrication associated with conventional felt clutches (such problems are, of course, magnified in high speed operation). Since other elements in the machine have also been designed for attention-free operation, the lubrication interval for the entire printer is extended beyond anything hitherto known in printing telegraphy:

60 speed–3,000 hours operation or 1 year } whichever
75 speed–2,400 hours operation or 9 mos. } occurs
100 speed–1,500 hours operation or 6 mos. } first



A VERSATILE ROBOT

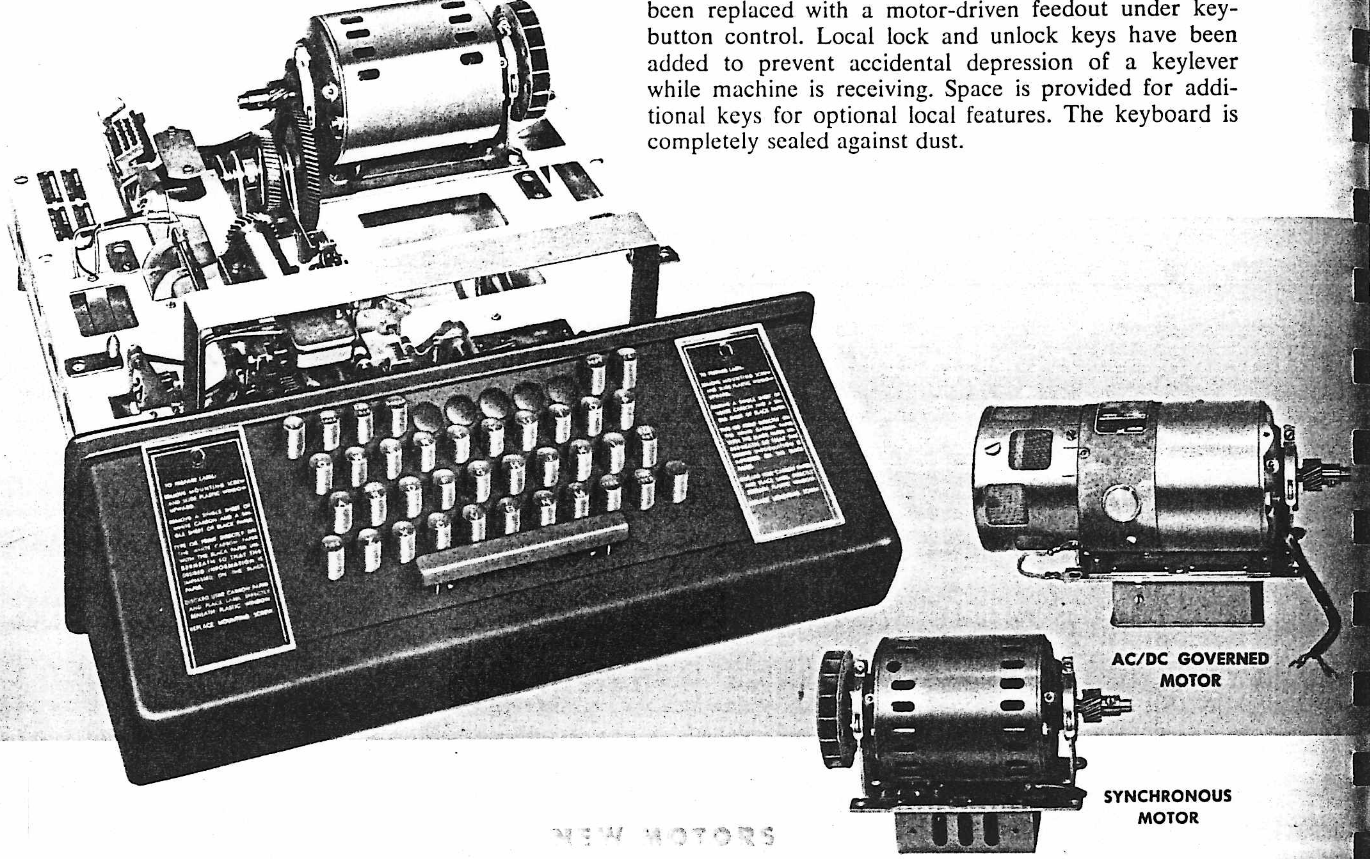
The Stunt Box in effect provides a third shift, devoted wholly to nontyping operations. Extending across the full width of the typing unit, it has 42 code spaces. Ten are reserved for the common functions—line feed, shift, etc. The remainder of the Stunt Box can become a built-in sequential selector to initiate mechanical motions within the machine or remote operations by means of electrical switches.

Thus a new vista is opened up for adding features without sacrificing key characters, for station selection without the expense of auxiliary equipment, for remote control operations of all kinds. For all practical purposes, the number of combinations available through sequential selection is limitless.

TELETYPE

SYMBOL OF LEADERSHIP IN PRINTING TELEGRAPHY

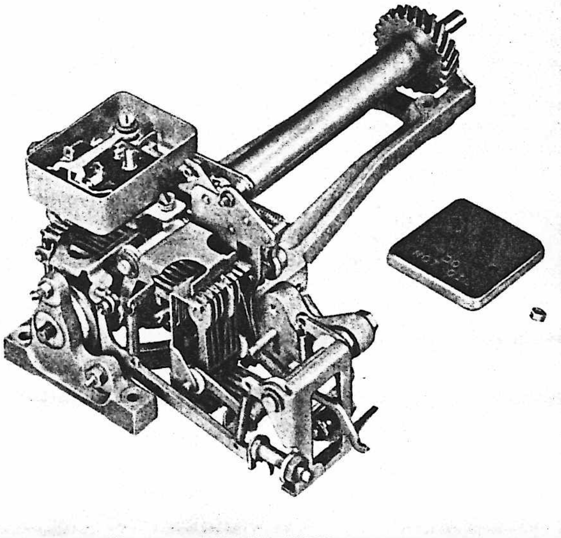
The Teletype 28 keyboard has been designed for maximum operator convenience. Power operation of the keyboard provides a light, uniform touch for all keys. Key design is modern, spacing between keys is the same as on standard typewriters. All local (off-line) controls have been brought to the keyboard; even the platen crank has been replaced with a motor-driven feedout under keybutton control. Local lock and unlock keys have been added to prevent accidental depression of a keylever while machine is receiving. Space is provided for additional keys for optional local features. The keyboard is completely sealed against dust.

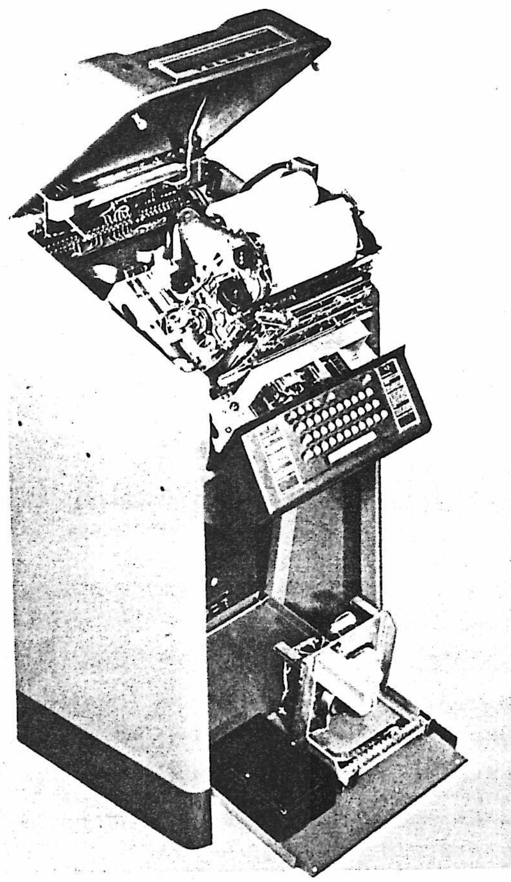


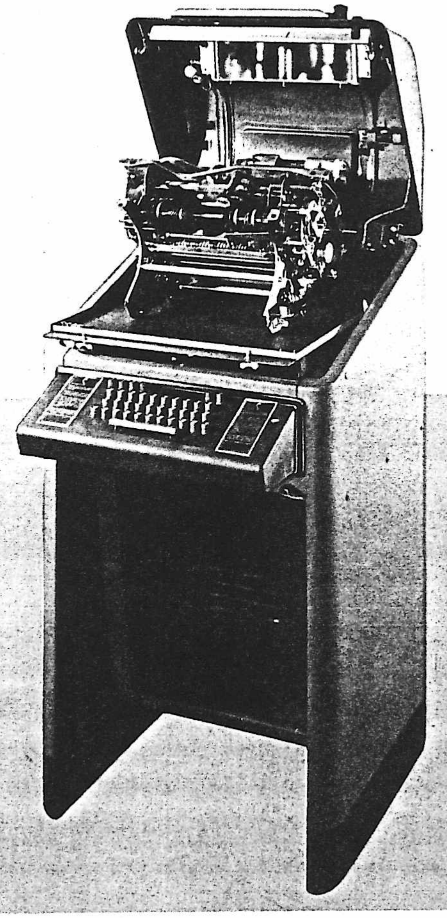
Motors have been specially designed for the Teletype 28, with emphasis on long life and attention-free operation. The synchronous motor has a rugged external relay in place of a starting switch, so the service man will have no need to open the motor. On the governed motor, the newly designed governor will hold its set speed for the life of the motor brushes (about 3,000 hours).

The motors have oversize ball bearings to obviate bearing trouble, and an air circulating system to take heat away rapidly. Both motors operate at 3600 r.p.m., use the same gears. Rubber mounts minimize noise.

A single contact assembly, mechanically operated by the distributor, replaces the conventional six-contact signal generator. The contact is mounted in a metal box for dust protection and shielding against radio interference. No adjustment is ever required, other than positioning the box itself.



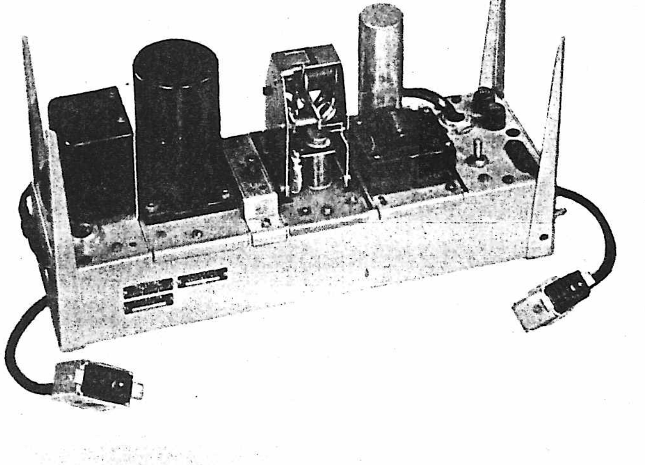




The smartly styled cabinet has been designed for operating convenience, noise suppression, and easy access for maintenance and for changing of ribbons and paper. A lamp within the cabinet illuminates the copy; the window above the copy has been set at an angle which minimizes glare. Since all mechanical controls have been brought to the front, cabinets may be placed in rows to conserve floor space.

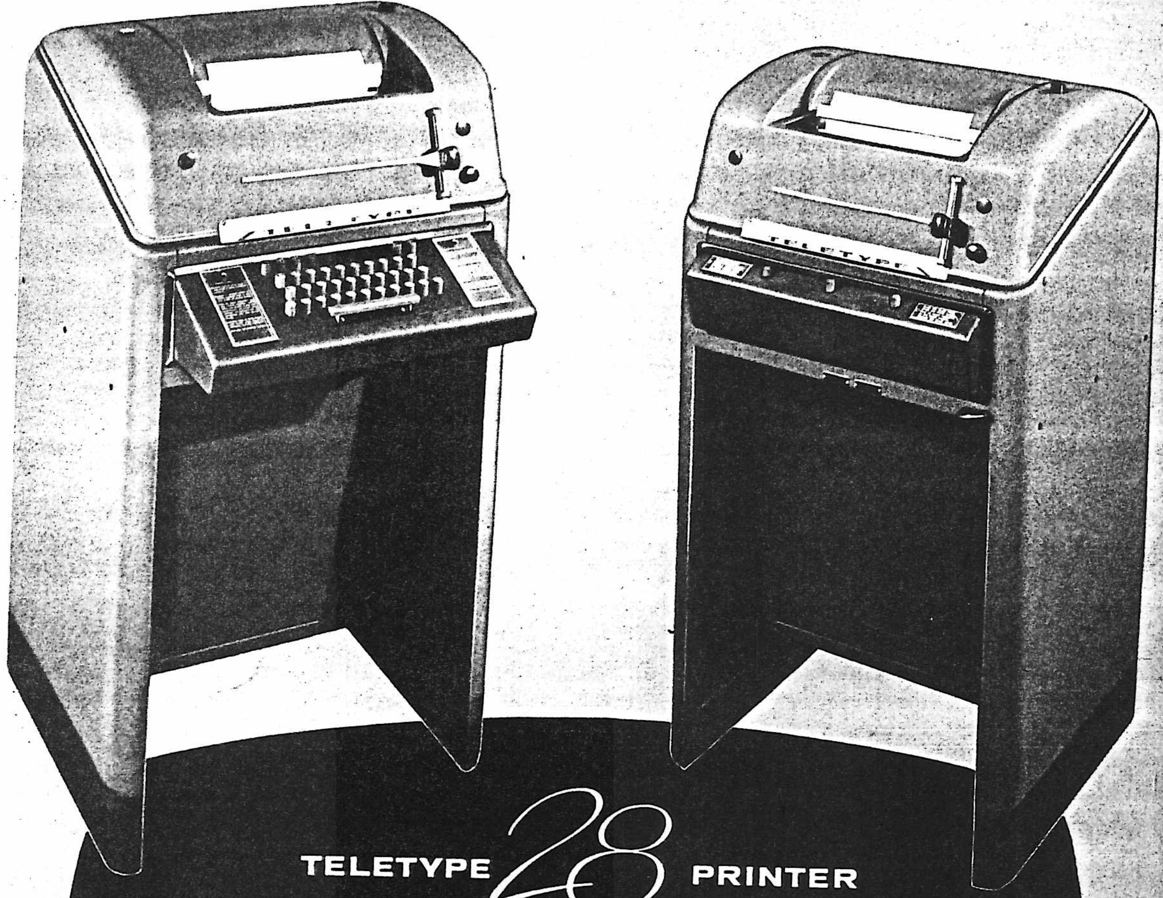
The cabinet hood swings open and will remain fixed in any position desired. The entire page printer keyboard set is mounted in a cradle so the set can be pivoted forward for access on all sides.

The lower front panel may be used for mounting additional station equipment, as shown in the photograph at the left. Or, if preferred, it can become a servicing tray, as shown in the photograph at the right.



ELECTRICAL SERVICE UNIT

Holds accessories such as line relay, rectifier, fuses, etc. Essentially it is a chassis, and the components are all packaged—for utmost flexibility in making up needed combinations. Interconnections between the various elements in the assembly have been made simple and adaptable, to permit installation of a standard machine under a variety of circuit termination requirements.



TELETYPE 28 PRINTER

Dimensions: Height 40½", Width 20½", Depth 18½".

Approximate Weights: Net—typing unit and keyboard, 38 Lbs.; electrical service unit, 7 Lbs.; cabinet, 75 Lbs. Domestic packed—total weight, 182 Lbs.

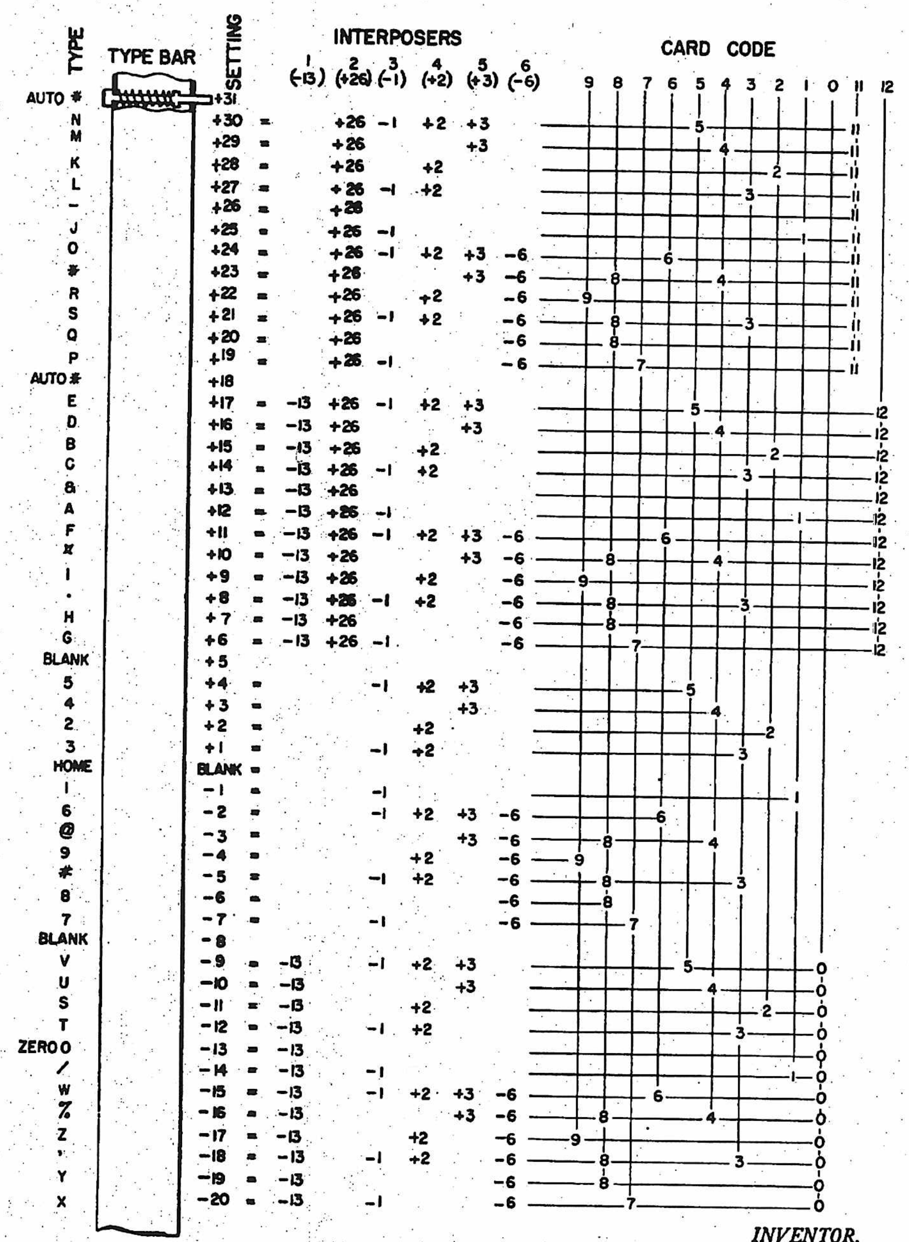
Finishes: Available in gray-green wrinkle or other standard finishes.

Power Requirements: Synchronous motor—65 watts at 115 Volts A.C., 60 cycles; Series governed motor—95 watts at 115 Volts D.C., 25-60 cycle A.C.

Optional Accessories: A variety of optional features and accessories are available.

TELETYPE CORPORATION
1400 WRIGHTWOOD AVENUE CHICAGO 14, ILLINOIS

Printed in U.S.A.



TYPE	SETTING		INTERPOSERS						CARD CODE											
			1 (-13)	2 (+26)	3 (-1)	4 (+2)	5 (+3)	6 (-6)	9	8	7	6	5	4	3	2	1	0	11	12
AUTO *	+31																			
N	+30	=		+26	-1	+2	+3						5						11	
M	+29	=		+26			+3							4					11	
K	+28	=		+26		+2										2			11	
L	+27	=		+26	-1	+2									3				11	
–	+26	=		+26															11	
J	+25	=		+26	-1												1		11	
O	+24	=		+26	-1	+2	+3	-6				6							11	
*	+23	=		+26			+3	-6		8				4					11	
R	+22	=		+26		+2		-6	9										11	
S	+21	=		+26	-1	+2		-6		8					3				11	
Q	+20	=		+26				-6		8									11	
P	+19	=		+26	-1			-6			7								11	
AUTO *	+18																			
E	+17	=	-13	+26	-1	+2	+3						5							12
D	+16	=	-13	+26			+3							4						12
B	+15	=	-13	+26		+2										2				12
C	+14	=	-13	+26	-1	+2									3					12
&	+13	=	-13	+26																12
A	+12	=	-13	+26	-1												1			12
F	+11	=	-13	+26	-1	+2	+3	-6				6								12
¤	+10	=	-13	+26			+3	-6		8				4						12
I	+9	=	-13	+26		+2		-6	9											12
.	+8	=	-13	+26	-1	+2		-6		8					3					12
H	+7	=	-13	+26				-6		8										12
G	+6	=	-13	+26	-1			-6			7									12
BLANK	+5																			
5	+4	=			-1	+2	+3						5							
4	+3	=					+3							4						
2	+2	=				+2										2				
3	+1	=			-1	+2									3					
HOME	BLANK	=																		
1	-1	=			-1												1			
6	-2	=			-1	+2	+3	-6				6								
@	-3	=					+3	-6		8				4						
9	-4	=				+2		-6	9											
#	-5	=			-1	+2		-6		8					3					
8	-6	=						-6		8										
7	-7	=			-1			-6			7									
BLANK	-8																			
V	-9	=	-13		-1	+2	+3						5					0		
U	-10	=	-13				+3							4				0		
S	-11	=	-13			+2										2		0		
T	-12	=	-13		-1	+2									3			0		
ZERO 0	-13	=	-13															0		
/	-14	=	-13		-1												1	0		
W	-15	=	-13		-1	+2	+3	-6				6						0		
%	-16	=	-13				+3	-6		8				4				0		
Z	-17	=	-13			+2		-6	9									0		
,	-18	=	-13		-1	+2		-6		8					3			0		
Y	-19	=	-13					-6		8								0		
X	-20	=	-13		-1			-6			7							0		

FIG. 17

INVENTOR.
ARNOLD B. CROWELL

BY William Lang
ATTORNEY

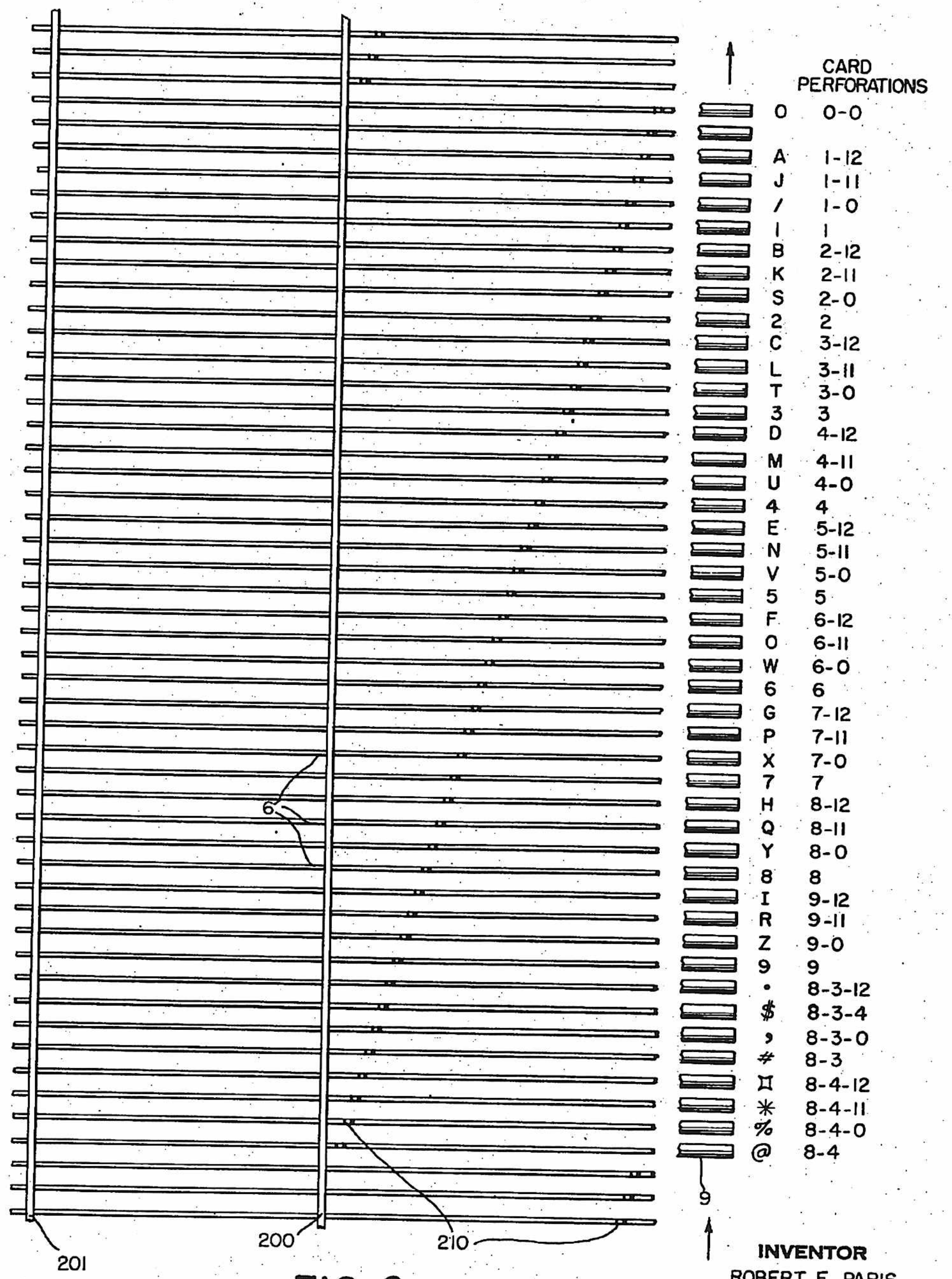


FIG. 6

INVENTOR
ROBERT E. PARIS
BY William Lang
ATTORNEY

No cover or title

Announced Oct 1954

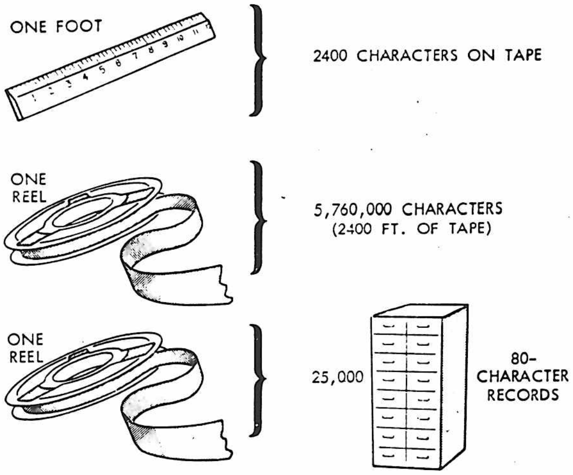


FIGURE 9. SCHEMATIC, MAGNETIC TAPE STORAGE

Record length on tape is extremely flexible and can be of any practical length within the capacity of memory. A record may thus contain one or several thousand characters. Variable record length makes possible the recording of complete historical data about a person or product in one record (Figure 10). Records are separated on the tape by a ¾ inch record gap. A record may also consist of a number of different fields and each field may vary in length.

Reels are rewound after reading or writing at an average rate of 500 inches per second, or an estimated 1.2 minutes for a full reel, allowing for acceleration and deceleration time. Reflective spots, placed on the tape by the operator at any desired point, are photoelectrically sensed to indicate the physical end of th tape and the load point.

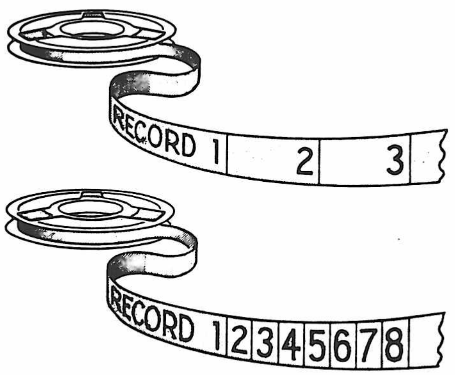


FIGURE 10. SCHEMATIC, VARIABLE RECORD LENGTH

CHARACTER CODE SYSTEM

FIGURE 11 illustrates the coding system used fo data recording on the IBM punched card. Punchin takes place in two main areas, the lower numeric section and the upper zone section.

The numerical section is further divided into t horizontal rows, one row for each digit 0-9. T zone section is divided into three horizontal row 0, 11, and 12. The zero row is common to bo zone and numerical sections.

The card is divided into 80 vertical columns. total of 80 characters may be punched in one car each character occupying one of the 80 columns.

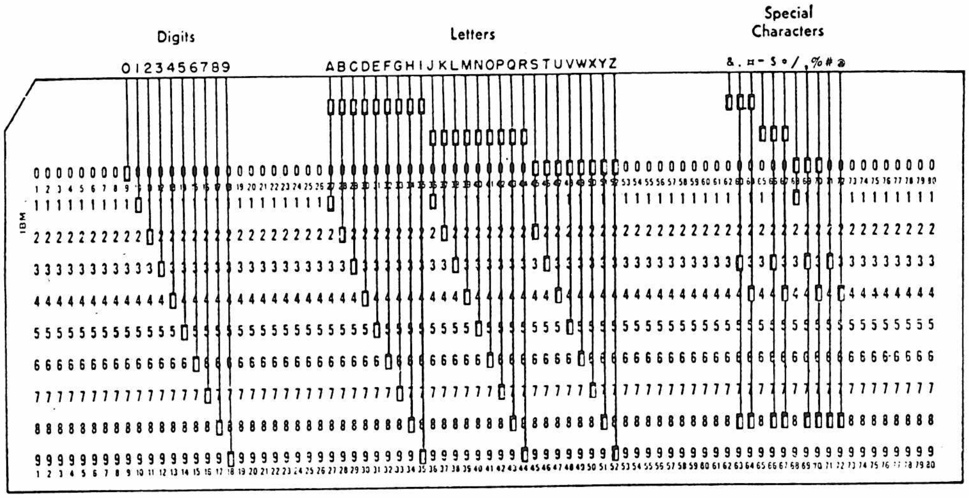


FIGURE 11. CHARACTER CODING, IBM CARD

When punched in their proper rows, holes can be automatically identified as characters by the 705 and other IBM accounting machines, the digits by single punches in the numerical section, and the letters of the alphabet and special characters by combinations of zone and digit punching.

The 12 zone with one of the digits 1 through 9 is recognized by IBM electric accounting machines as one of the letters A through I, the 11 zone with the digits 1 through 9 as J through R, and the 0 zone with the digits 2 through 9 as S through Z. Eleven special characters are recognized by the various combinations of zone and digit punches shown in Figure 11.

Figure 12 represents a section of magnetic tape with 705 character coding shown schematically. Actually, recording is not visible to the eye.

The tape is divided into three sections:

1. The zone section of two horizontal rows or "tracks," called A and B.
2. The numerical section of four tracks, each track with an assigned value of 8, 4, 2, or 1, respectively.
3. The checking section of one track, called C, used for checking purposes only.

Recording is accomplished by changing the state of magnetization of the oxide coating on the tape from positive to negative or from negative to positive. The change in magnetization represents a one; the lack of change represents a zero. The arrangement of these ones and zeros in combinations in the seven tracks forms digits, letters, and special characters.

Ones placed in the proper numerical tracks are used to represent digits. For example, the digit 6 is represented by placing a one in tracks 4 and 2, thereby making the total value of the ones equal to 6. All other tracks are zero.

The same code structure used by electric accounting machines is also used by the 705 to represent letters and special characters. A one in both A and B tracks represents the 12 zone, a one in the B track with a zero in the A track represents the 11 zone, and a zero in the B track with a one in the A track represents the zero zone. A zero in both A and B tracks corresponds to no zoning on the card when only numerical rows are punched. The various combinations of ones in the zone and numerical tracks used to represent letters and special characters are also shown in Figure 12.

The check channel contains a one whenever the sum of the ones in the numerical and zoning portions of the character is odd, and a zero if the sum of the ones is even. The machine performs a character-code check on the transmission, reading, and recording of all data, to insure that each character has an even total number of ones including zone, numerical, and check positions.

The code system shown on tape in Figure 12 is used in all components of the 705, including memory, accumulator and auxiliary storage, and drum storage.

The conversion of the 705 code system to or from IBM card code is automatic whenever a card reader, printer, or punch is used.

INPUT-OUTPUT DEVICES

Data can be entered into the 705 system from both IBM cards and magnetic tape. Results can be printed, punched into IBM cards, or written on magnetic tape, all in the same procedure. Any practical number of input or output devices—such as card readers, tape

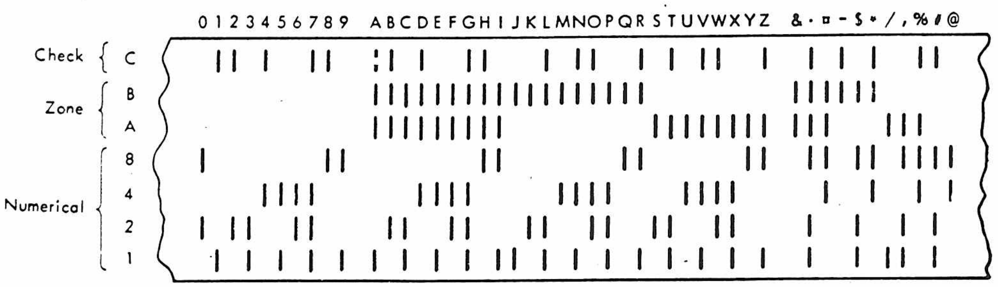

0 1 2 3 4 5 6 7 8 9 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z & · ¤ - $ * / , % # @
Check
C
Zone
B
A
Numerical
8
4
2
1

Figure 12. Character Coding, 705 EDPM

	CHAR.	C	BA	8421	CHAR.	C	BA	8421	CHAR.	C	BA	8421	CH.	C	BA	8421	
	&	0	11	0000	-	1	10	0000	Blank	1	01	0000	Acc. and Drum Mark 0	0	00	0000	
ALPHABETIC	A	1	11	0001	J	0	10	0001	/	0	01	0001	1	1	00	0001	NUMERICAL
	B	1	11	0010	K	0	10	0010	S	0	01	0010	2	1	00	0010	
	C	0	11	0011	L	1	10	0011	T	1	01	0011	3	0	00	0011	
	D	1	11	0100	M	0	10	0100	U	0	01	0100	4	1	00	0100	
	E	0	11	0101	N	1	10	0101	V	1	01	0101	5	0	00	0101	
	F	0	11	0110	O	1	10	0110	W	1	01	0110	6	0	00	0110	
	G	1	11	0111	P	0	10	0111	X	0	01	0111	7	1	00	0111	
	H	1	11	1000	Q	0	10	1000	Y	0	01	1000	8	1	00	1000	
	I	0	11	1001	R	1	10	1001	Z	1	01	1001	9	0	00	1001	
	Plus Zero 0	0	11	1010	Minus Zero 0	1	10	1010	Record Mark	1	01	1010	Numerical Zero 0	0	00	1010	
SPECIAL CHAR	.	1	11	1011	$	0	10	1011		0	01	1011	#	1	00	1011	
	¤	0	11	1100	*	1	10	1100	%	1	01	1100	@	0	00	1100	
	Group Mark	0	11	1111									Tape Mark	0	00	1111	

FIGURE 121. CHARACTER CODE CHART

~~PROF. GEORGE E. FORSYTHE~~
DEPARTMENT OF MATHEMATICS
STANFORD UNIVERSITY
STANFORD, CALIFORNIA

20

650

magnetic drum data-processing machine

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manual [illegible]

MAJOR REVISION (June 1955)

This edition, Form 22-6060-1, obsoletes Form 22-6060-0 and Form 22-6149-0. Significant changes have been made throughout the manual, and this new edition should be reviewed in its entirety.

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Printed in U. S. A.
Form 22-6060-1

OFFSET STACKING DEVICE

An OFFSET STACKING DEVICE is available for installation on the punch stacker. This device is used to locate specified cards by offsetting them in the punch stacker 3/8″ toward the front of the machine. The operation of this device is controlled by control panel wiring to the OFFSET hubs (AQ, 51-52).

Examples of control panel wiring to control the offset stacking device are shown in Figures 102 and 103.

Wiring (Figure 102)

1. The card in which a double-punched or blank-column error was detected is offset in the punch stacker.
2. The digit impulses read in column 80 by the punch brush enter the common of the punch column splits.
3. The 11 or 12 impulses read in column 80 activate the punch delay device.
4. The offset stacking device is activated one cycle after an 11 or 12 card identification punch has been read in column 80 by the punch brushes. The identified card will be offset in the punch stacker.

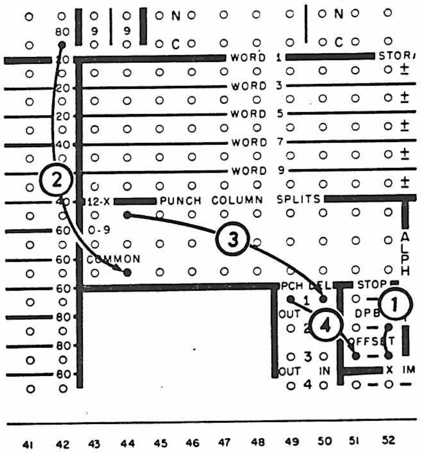


FIGURE 102. OFFSET STACKING

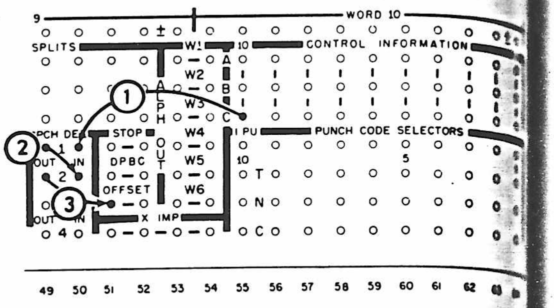


FIGURE 103. OFFSET STACKING

Wiring (Figure 103)

1. The punch delay device is activated b control information impulse when an eight the tenth position of word 10.
2. This wire causes a second cycle delay.
3. The offset stacking device is activated two after the control information impulse identifi card to be offset. The identified card will be of the punch stacker.

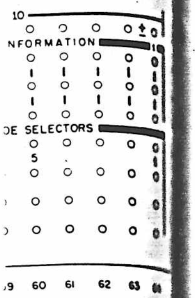
ALPHABETIC DEVICE

THE ALPHABETIC DEVICE provides a maximum and output of 30 alphabetic positions distribut the first 6 storage entry or storage exit words. device will handle all 26 alphabetic characters the 10 numerical digits. Special characters ar cluded.

Transfer of pure alphabetic or alphabetic-num information from read input to punch output i sible. The alphabetic input may be used logica the program for table look-up arguments and operations as required. Those entry words, desig by control panel wiring as alphabetic, have the try information translated in the entry scanning cuits into a 10-digit numerical word. From that on, the translated word is handled internally other numerical word.

The coded alphabetic-numerical informatio sumes the following sequence relationship inter

Deal



STACKING

is activated by
hen an eight

l cycle delay.
s activated two
impulse identifi
card will be off

EVICE

ides a maximum
ositions distribu
rage exit words
abetic characters
ial characters a

r alphabetic-nu
o punch output
ay be used logic
o arguments and
ntry words, desi
habetic, have th
the entry scann
word. From th
dled internally

erical inform
relationship in

Character	Card Code		Type 650 Code
Blank		=	00
A	12-1	=	61
B	12-2	=	62
C	12-3	=	63
D	12-4	=	64
E	12-5	=	65
F	12-6	=	66
G	12-7	=	67
H	12-8	=	68
I	12-9	=	69
J	11-1	=	71
K	11-2	=	72
L	11-3	=	73
M	11-4	=	74
N	11-5	=	75
O	11-6	=	76
P	11-7	=	77
Q	11-8	=	78
R	11-9	=	79
S	0-2	=	82
T	0-3	=	83
U	0-4	=	84
V	0-5	=	85
W	0-6	=	86
X	0-7	=	87
Y	0-8	=	88
Z	0-9	=	89
Zero	0	=	90
1	1	=	91
2	2	=	92
3	3	=	93
4	4	=	94
5	5	=	95
6	6	=	96
7	7	=	97
8	8	=	98
9	9	=	99

When a word is alphabetically coded, the number of digits involved is doubled. For example, a part number 5A72R is recoded as 9561979279. If more than five characters are involved, and the alphabetic information is interspersed at random, at least two alphabetic words must be used. Alphabetic words are automatically read into the machine as positive numbers.

The device is flexible from a capacity standpoint. Any number of input words from 0 to 6 may be designated as alphabetic by selective control panel wiring. Similarly, any number of output words from 0 to 6 may be made alphabetic. The output words may be controlled by either internal programming or control panel wiring. The same words need not be designated as alphabetic on both input and output.

The alphabetic designation may vary from output card to output card as required by control panel selection. Because the zone portions of the alphabetic characters are read at first reading, it is impossible to use field selection on alphabetic fields in the normal manner. Alphabetic field selection may be accomplished as shown on pages 108 and 109.

Alphabetic Input Hubs

Alphabetic in entry hubs *(AL-AR, 11-12)* receive impulses to set up the corresponding storage entry word to receive alphabetic information. These hubs may be constantly impulsed from the CONSTANT ALPHABETIC IMPULSE (CAI) exit hub or selectively from the COUPLE EXIT of a pilot selector.

CAI exit hub *(AK, 12)* provides a constant alphabetic impulse except during load cards. This may be used to impulse the desired ALPHABETIC IN hubs.

Alphabetic first read entries *(AK-AM, 13-22)* are normally wired from first reading. The alphabetic columns to be read from the card are entered directly as required.

The normal STORAGE ENTRY hubs of the alphabetic words must be impulsed from second reading. The card columns to be entered are wired to the five low-order digits of the storage entry. Each alphabetic or numerical character is internally translated to a standard two-digit number for use in the computer.

NOTE: When the word in question is alphabetic, the word size entry is always wired for word size 10.

Alphabetic Output Hubs

Alphabetic out entry hubs *(AK-AQ, 53-54)* receive impulses to convert the corresponding storage exit words to alphabetic output. These entry hubs normally receive impulses from CONTROL INFORMATION when selective control is required. If constant alphabetic output is required, an impulse is entered from the PSU exit, V-41.

The normal STORAGE EXIT hubs are wired to the selected punching positions, using the five low-order exits of the alphabetic word.

NOTE: This is possible since the alphabetic first read hubs identify a card column as having a zone (12, 11, 0) and/or a numeric (1-9). It does not identify the particular zone or the particular numeric. Blanks are identified by the absence of the zone and numeric.

METHOD D. Completely flexible alphabetic field selection is possible within the selector capacity of the machine. The card for which field B is to be selected (field A is the normal field) must be identified by either a 12 or an 11 punch. The method used depends upon the fact noted above and operates as follows:

1. Pilot selectors are transferred whenever an X or 12 occurs on either of the two fields.
2. A pilot selector (No. 11) is transferred by the control X or 12.
3. A digit emitter zero is selected to test either the field A pilot selectors or the field B pilot selectors.
4. The output from the selectors (a zero) substitutes for the corresponding 12 or X-impulse and is wired into ALPHABETIC FIRST READ along with the correct numeric (1-9) for the selected field.
5. The storage entry wiring is selected in the normal manner.

SPECIAL CHARACTER DEVICE

A SPECIAL CHARACTER device is available for the Type 650. This device is available in two different groups and is capable of handling special characters. The number of special characters that this device will handle will be dependent on the group specified. The available groups and their capacities are:

1. Group I will handle eleven and twelve punches only.
2. Group II will handle all Type 407 special characters including eleven and twelve punches only.

NOTE: The foregoing discussion of alphabetic selection does not apply when the special character device is in use.

Each character that is to be handled by the special character device is automatically recoded into a two-digit number. The sequence of the special character code and the standard alphabetic code is the same as that of the Type 89 Alphabetic Collator; for example, blank, special characters, alphabetic, and numeric from the lowest to the highest order. The numerical representations of the complete code are:

CHARACTER	CARD CODE		TYPE 650 CODE	
Blank		=	00	Standard Alphabet Special Characters Group I, II
.	12-3-8	=	18	Special Characters Group II
□	12-4-8	=	19	
&	12	=	20	Special Character Group I, II
$	11-3-8	=	28	Special Characters Group II
*	11-4-8	=	29	
-	11	=	30	Special Character Group I, II
/	0-1	=	31	Special Characters Group II
,	0-3-8	=	38	
%	0-4-8	=	39	
#	3-8	=	48	
@	4-8	=	49	
A	12-1	=	61	Standard Alphabet
B	12-2	=	62	
C	12-3	=	63	
D	12-4	=	64	
E	12-5	=	65	
F	12-6	=	66	
G	12-7	=	67	
H	12-8	=	68	
I	12-9	=	69	
J	11-1	=	71	
K	11-2	=	72	
L	11-3	=	73	
M	11-4	=	74	
N	11-5	=	75	
O	11-6	=	76	
P	11-7	=	77	
Q	11-8	=	78	
R	11-9	=	79	
S	0-2	=	82	
T	0-3	=	83	
U	0-4	=	84	
V	0-5	=	85	
W	0-6	=	86	
X	0-7	=	87	
Y	0-8	=	88	
Z	0-9	=	89	
Zero	0	=	90	
1	1	=	91	
2	2	=	92	
3	3	=	93	
4	4	=	94	
5	5	=	95	
6	6	=	96	
7	7	=	97	
8	8	=	98	
9	9	=	99	

The Role of Communications Networks in Digital Data Systems

R. C. MATLACK†

Summary—Communications have played an important role in linking together teletypewriters in manual and automatically switched networks. There is a rapidly growing need for higher speed communications to transmit digital data from remote to centralized locations. New engineering and maintenance approaches are necessary to take advantage of the existing widespread voice communication facilities. Since this plant has been primarily designed for voice transmission, new techniques are desirable to insure reliable high speed data transmission and switching. This would be facilitated by use of a universal language and standardized speeds of transmission. The speaker will discuss these problems as viewed by a communications supplier and will present his views on future development.

I AM SURE that we have all dreamed of the future possibility of having quick and easy access to an electronic computer in order to obtain from its memory a fast and painless answer to a question. As extensive decentralization has taken place in industry, it has become more difficult to keep top management informed with *up to the minute* data regarding all phases of operation. It is almost universally believed that this difficulty will be overcome by high speed transmission of current information to a centralized data processing center from a large number of remote locations. Obtaining easy access to a computer from remote locations and keeping its memory current, is a problem of communications requiring the use of a digital language. In recent years, even the general public has become accustomed to seeing information represented in coded form on punched cards. In the Bell System, we have developed extensive record communication services based on punched paper tape.

Coding by marking or punching is an old art. The speed capability of electronics has necessitated the development of new recording methods such as magnetic tape which, in turn, accentuates the need of higher speed communications systems. Computer engineers have suggested that the existing widespread telephone network may be utilized to rapidly accelerate the use of systems which will automatically process practically all types of existing business records. Before discussing these future development possibilities, I would like to briefly discuss existing data communications networks in order to provide some background information which I feel will help in an understanding of the future, since most developments are evolutionary rather than revolutionary in nature.

Communications have played a vital role in the transmission of data ever since Morse devised his well-known code in 1838. This was followed shortly thereafter by successful telegraph printers. In 1874, Emile Baudot greatly accelerated this progress with his 5 unit selecting code which became, and still remains, the common language code for telegraph printers, more familiarly known as teletypewriters.

Two general types of services are now furnished by the Bell System. These are known as (1) teletypewriter exchange service, commonly referred to as TWX and (2) private line services.

The Bell System TWX service is furnished to fill the need of customers who have a limited amount of point-to-point data to transmit per day or have the need to communicate with any of a large number of other TWX customers. An example of this latter case is the need of a travel bureau of a company to quickly arrange and confirm wide-spread hotel reservations for its employees. At the present time in the Bell System, there are approximately 37,000 teletypewriter exchange stations employing 3,352,000 miles of circuits. The system averages approximately 89,000 calls per business day with each call averaging 8 minutes. Messages are transmitted either *on line*, as they are typed by the keyboard operator, or automatically, by placing a previously prepared perforated tape into a transmitter distributor. Speed is limited in the *on line* case to the capability of the operator whereas the automatic method is limited by the system capability, which is 60 words per minute.

The second, or private line type of services are quite varied in nature. There are service offerings of teletypewriter, voice, telephoto, facsimile, telemetering, program, and television. In the data transmission field, these private line circuits are capable of information rates varying between the limits imposed by a 170 cycle telegraph channel to a 4.5 mc television channel. At the present time, the largest Bell System private line service is teletypewriter. It runs the gamut from leasing a pair of wires to a customer who furnishes his own teletypewriter terminal equipment, to the leasing of a complex automatic switching system and wire network along with the associated teletypewriter equipment. These large automatic systems compare in functional complexity to modern computers. They play a vital role in data processing systems now in use by many large companies.

Private line teletypewriter service is furnished to a particular customer for his exclusive use for a specified period. These periods range from eight hours per day on specified days, up to twenty-four hours per day, seven days a week. A few typical arrangements are: 1) point-to-point service, 2) party line service, where a

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† Special Systems Engineer, Bell Telephone Labs., New York, N. Y.

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number of stations are all connected to one line and one or more are arranged to only receive; this type of service is arranged for various press associations who sometimes have as many as 300 to 400 stations on a line, and 3) large automatic message switching systems. A typical large system in use consists of 2 switching centers, 94 sending stations, 143 receiving stations, and 23,000 circuit miles. Daily traffic averages 48 thousand messages with an average length of 17 words. Automatic switching is accomplished by the use of address characters preceding the message and by end of message characters following the message. Bell System private line teletypewriter services now aggregate approximately 42,000 stations employing about 4,000,000 miles of circuits, which is slightly greater than the TWX service with regard to both stations and circuit miles. A cost of $0.11 per message is experienced by one company which has an efficiently loaded, large system. In this case, the message averages 40 words in length and travels 500 miles. This cost represents only the revenue paid to the Bell System and does not include additional company operating costs.

Teletypewriter services now in use have nominal speed capabilities of 60, 75 or 100 words per minute, with corresponding bit rates per second of 46, 57, and 74 based on the standard 5 unit code. An average teletype word is assumed to be 5 characters plus a space. No error detection facilities are provided, but these services are engineered to rigid transmission standards. Circuits are engineered from end-to-end so that the error rate is never worse than one in 44,000 characters. Average telegraph circuits, however, have transmission error rates of about one in 8,000,000 characters. These error rates include the normal random summation of various sources of transmission distortion, but do not include distortion due to interruptions, static, magnetic storms, etc. The above error rates cover only the transmission and do not include operator amd machine errors. A regenerative repeater which retimes the signal elements is inserted in over-all circuits comprised of many links, in order that the transmission standards will be met.

The teletypewriter services were planned primarily as a means of communicating ordinary text. Because teletypewriter machines do not use an error detecting code, computer people have sometimes been reluctant to use the service for business and other nonredundant data. In view of the high degree of error control maintained, as described above, the teletype service is suited to many business uses. The automatically switched networks should, in particular, be of interest to those designing integrated data processing systems. Work is underway to develop an economical and reliable error detecting scheme for use with the 5 unit code.

Having looked at the present facilities for transmitting data, let's look at the future. In the first place, it is now clear that high speed digital data communication is going to be necessary to support the further mechanization of business and industry. At the present time there is a growing need to transmit data in the fastest possible manner from widespread remote locations to centralized data processing centers in order that information there may be as current as possible. In fact we in the Bell System have had numerous inquiries from manufacturers of computers and business machine equipment, as well as from users of such equipment, as to what developments are planned for use over private line networks and for use over the telephone network.

In the private line field, it is possible to utilize channels which vary in discrete steps of bandwidth all the way from telegraph to television. Examples are: voice channels with upper usable frequencies varying from 2,400 to 3,300 cycles; 5,000 and 15,000 cycle program channels; carrier group channels such as 48 and 96 kc and 4.5 mc television channels. At the present time, only the voice and telegraph channels are being used for data transmission, but the broader channels, along with suitably designed modulators and demodulators will be considered when the demand materializes for higher speed data transmission systems. We have, under development for the SAGE project, a data transmission system capable of transmitting 1,600 bits per second over a private line facility. In order to realize this speed of transmission, the circuits must have some delay equalization treatment and some of the carrier systems must be adjusted to improved impulse noise standards. Also under development, is a double sideband amplitude modulation system with an expected capability of transmitting 750 bits per second over a standard voice bandwidth private line facility. The Teletype Corporation has, under development, a punched paper tape transmitter and receiver which can be arranged for 5, 6, or bit codes and a speed capability of 60 to 100 characters per second.

Computer engineers have made numerous inquiries regarding the possibility of the Bell System's using the regular telephone switched network for data transmission. It has been pointed out that this is particularly attractive to small businesses and agencies who have limited amounts of traffic and desire to transmit small volumes of traffic on an intermittent basis. Since the network is practically universally available and is rapidly being arranged for customer direct distance dialing within the United States, it has very attractive possibilities for this use. It has been proposed that the telephone be used in the usual manner to establish a connection to a data processing center. As soon as the connection is established, a suitable data input device would be substituted for the telephone.

I would like to discuss now some of the engineering problems in connection with this particular proposal. As you know, the telephone plant has been basically engineered for voice transmission and the only criterion is that a satisfactory voice transmission circuit will be furnished. However, voice transmission requirements are much less severe than data transmission requirements, particularly with respect to impulse noise and delay distortion. The telephone plant is made up of many different kinds of voice and carrier facilities which vary widely in bandwidth, delay, and noise characteristics. Slow speed data transmission in the form of direct current dial pulses and numerous alternating current signaling and data transmission schemes are widely used to establish and disconnect telephone connections. Several years ago, the Bell Telephone Laboratories initiated a research program to acquire fundamental knowledge of high speed data transmission over telephone circuits. The main purposes of this program were to explore faster and more efficient ways of establishing telephone connections. Much has been learned from this and other similar projects regarding high speed data transmission over telephone circuits.

Extremely high accuracy of data transmission is a must, and this presents a most pressing problem. The general trend in the computer field has been to add parity checking to all data processing equipment and arrange the characters in block form on magnetic tape with space between the blocks. Block lengths vary between approximately 70 to 120 characters. A likely way of transmitting them is by start-stop operation, whereby checking equipment at the receiving end will, at the end of a block, send a return signal to the transmitting end to advance to the next block if there were no errors, or back up and repeat the block in the event there were one or more failures to parity check or check that the correct number of characters per block were received. A considerable amount of study and experimenting is necessary to determine the optimum block length for transmission purposes. If the block is too long, too much time will be wasted by retransmission of blocks that have only one error. If, however, the block is too short, the return signal time will become an appreciable part of the transmission time. This is greatly aggravated by echo suppressors which are used on electrically long circuits in order to prevent the annoying return signal. Transmission is possible in only one direction at a time since the opposite direction is purposely suppressed in order to avoid echoes. As the direction of transmission is reversed, the echo suppressors do not immediately reverse, but take as much as 120 milliseconds on a long circuit such as from coast to coast. This is not noticeable in voice transmission, but is a time loss with data transmission.

Many of our modern carrier systems are designed with compandors which is an abbreviation for compression and expansion. Their purpose is to compress loud speech and expand weak speech at the transmitting end and reverse this process at the receiving end. By means of these compandors, very decided signal-to-noise advantages are obtained for voice, and transmission is much improved over noisy circuits. These decided signal-to-noise advantages lead, of course, to an engineering of the telephone channel with a correspondingly greater physical noise before the compandor is inserted, than would be the case if the channel were to be used without compandor. This higher noise level is detrimental to pulse type transmission and therefore special design measures are necessary to make a high speed data transmission system function reliably over compandored facilities. In spite of these difficulties from a technical viewpoint, it appears possible to design a fast, highly reliable data transmission system suitable for use over the telephone switched network. The primary function of the network, however, is to carry telephone conversations and this function must not be jeopardized. Special input and output lines (*i.e.*, subscribers' loops) and additional facilities to increase the traffic capacity of the network probably would be minimum requirements.

It is interesting to speculate as to what type of services might be provided. Indications so far are that there will be need for two distinct types: a very simple slow speed arrangement whereby a message can be sent by a simple keyset to a computer or machine and a return answer by voice from a computer or machine; and a means of sending all forms of digital data from tape to tape at the highest possible speed. An example of the first case would be if you wanted to find out how many piece parts of a specified number were in stock at a given factory. Connection to a computer might be achieved by dialing a telephone number type code, followed by a proper code to determine how many of the desired piece parts are available. The computer would give the answer in digital form, or by means of a convertor the answer might be transmitted back to you in voice. This is, of course, a very simple arrangement and many variations of increasing complexity are possible. For example, the question could be transmitted by means of a teletypewriter and the computer would type the answer on the teletypewriter. This type of service is *on line* transmission, but since it is visualized that a high percentage of this type of traffic would be local in nature, high speed is not a vital factor.

A large number of speculative types of service are possible which involve the second type of service which was previously mentioned. These types of service involve the transmission of all forms of digital data from tape to tape at the highest possible speed. A typical example would be a typewriter keyboard associated with the necessary equipment to code the characters on magnetic tape as they are being typed. When desirable, the tape would be placed in a transmitter and the information sent over a connection after being established by dialing in the conventional manner. The necessary equipment at the receiving end would place the signals on a tape which would be a duplicate of the sending tape. Included would be the necessary checking equipment to advance the transmitting tape block by block as previously discussed. A great many variations of this basic plan are possible. For example, one might conceive a mixture of all different types of digital data placed on the tape in message form such as computer data, punched card data, and teletypewriter data. This would require that messages of different types be preceded by characters indicating the type of data and followed by end of message characters. It would be possible to place the tape in a suitable reader associated with switching equipment which could monitor the code directing characters and transmit the message to the proper end equipment such as computer, card reader, or teletypewriter. It is obvious that this type of switching requires a common language code in order that certain characters can be reserved for only that use. I would like to urge that serious consideration be given to standardization in the field of data transmission. I realize that rigid standardization is undesirable because it tends to stifle the progress of a newborn art. I feel, however, that some reasonable amount of standardization which will not block progress is possible and will avoid a lot of future headaches.

I would like to emphasize that the discussion regarding the use of the telephone switched network has been entirely speculative in nature for the purpose of sti lating some thinking regarding the long range asp of the data transmission field. I would also like acknowledge that much of the information regardi the existing TWX and private line systems was obtai from Messrs. L. A. Gardner and E. R. Robinson Bell Telephone Laboratories.

Concluding ideas are summarized as follows:

1) The continued mechanization of business require expanded digital communication facilities. less the communication problems are solved, the benefits of mechanization will not be realized.

2) The computer and the communication indus each need the cooperation of one another in work out standards for data transmission.

3) And finally, let me say to all those designing tegrated data processing systems, "Don't leave the munications problems until the end. Call in a comm cations man early in the project and use his special knowledge to help you design an optimum system

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Discussion

J. H. Waite (R.C.A.): Are you aware of any efforts being made to develop error detection and auto-correction techniques for teletype communications?

Mr. Matlack: Yes, as mentioned yesterday by Mr. Fitzgerald, although I am not aware of it, Western Union is working on that and I mentioned that the Bell System is also working on it. Of course, an obvious way of including error detection is to transmit the message twice. This is a waste of time and better methods can be used. Error correction requires much more redundancy and we feel it is sufficient to be able to know that there is an error without correcting it; that is, action can be taken if you know an error is there rather than include all the redundancy necessary to correct the error.

M. S. Rubin (Filene's): Is it now possible to transmit seven channel magnetic tape data over a conventional telephone wire, not teletype? If not, what can you tell us about current work being done?

Mr. Matlack: It is not presently possible and, as I indicated to you in my conclusion, I have only spoken about the engineering considerations of this. There are many policy questions involved which have not as yet been resolved regarding the use of the telephone switched network for this type of service.

Capt. B. R. Jacobellis (Signal Corps): What form will the error detecting code take?

Mr. Matlack: Is this with respect to teletype or the future type system? In the case of the teletype system there are several possible ways of doing this, such as on a per line basis. When the carriage returns to the next line it is possible to add across the rows of characters and come out with what is equivalent to a sum, odd or even, and type whatever random character happens to come up there. That is one way of doing it and was mentioned by Mr. Fitzgerald yesterday.

There are other ways of adding every so often, say every 20 characters, or 30, or whatever you want to pick and how accurate you want to make the system. You can add a redundancy check character and then remove it at the terminating end.

With regard to future systems I think it leans towards a seven bit code with one of these as a check bit.

E. L. Lach (Western Union): What percentage of accuracy can be expected with the five channel error check under development with your firm?

Mr. Matlack: I can not answer that at the present time because we have not tested it.

C. K. Budd (Signal Corps): Is the Bell System interested in standardization of digital code language and if so, what is the present status of work on such a project?

Mr. Matlack: Preliminary discussion with interested computer manufacturers and users has been started under the sponsorship of the JCC. I think this will come out more in the panel discussion that is coming along. I would prefer to delay this question until that time.

W. L. Poland (Daystrom Instr.): In transmission at 750 bits/sec over typical voice lines, what is the expected average error rate?

Mr. Matlack: This is going to depend, as I mentioned in the paper, on how long we make the block length. Nothing has been picked as yet and tests are just now beginning to determine error rates. It is very dependent on how long the block length is. If you make the block indefinitely long there is bound to be an error in transmission to upset some of the characters. Ho if the block is only a few characters lo chance of an error is practically impo Therefore, some compromise has effected as to block length.

H. E. Tompkins (Burroughs): Ho the ratio of cost to bandwidth vary different bandwidth channels availab

Mr. Matlack: In the private lin in the Bell System the higher you bandwidth the cheaper it is in terms For example, consider slow speed tel writer at 100 words a minute. The line charge is roughly $1.50 a mile per An ordinary voice channel, which stead of 100 words per minute, a cap of roughly a thousand words a min $3 a mile per month. That goes up to 4.5 mc which is in the order of $35 a There are additional terminal char connecting it in at the time it is con However, that gives you an idea. Th per bit is going down tremendously as width goes up.

J. McDonnell (IBM): A large puter installation costs $2 to $5 per h operate. Do you know the comp costs for voice, radio, carrier and for a 1,000 mile station to station ope

Mr. Matlack: No, I can't give y comparative breakdown of that. Of our voice facilities are carved out of different things, such as our coaxial and our microwave relay. All of those use for providing transmission. I thi do know pretty well, if you take a sta station toll charge rate on the teleph thousand mile call would be rough three minutes on the order of $1 to That would be my guess without looking at a rate schedule. In this minutes you could transmit in the o say at the rate of 700 bits per seco that extended over your three minute you are pumping in a fair amount of information, particularly if it is coming from one isolated spot, and this is the point we should all keep in mind.

When you eventually get down to it someone has to make these records. When you talk about millions of bits you are talking about a lot of people originating data. In cases of short transmission time you can handle the output work of small offices quite easily. When you get into the higher echelons with computing centers, the need for high speed transmission and longer times becomes necessary. Where you can take a private line facility and keep it loaded a high percentage of the 24 hours it is the most economical method.

E. Donahue (IBM): Has Bell experimented in the field of data transmission through short wave radio hookups and, if so, what results have been obtained?

Mr. Matlack: No, we have not expressly experimented with the short wave radio. However, our ordinary teletypewriter transmission facilities are going over microwave relay in some cases from coast to coast. There are voice channels carved out of the microwave system which are carrying teletypewriter messages.

L. J. Score (Commercial Controls Corp.): Has any thought been given to six, seven, eight bit transmission with parity or other checks?

Mr. Matlack: Yes. As I mentioned, I think, in connection with an earlier question on the longer range aspects of this problem, we are considering a seven bit code. Our difficulty with the teletypewriter five unit code—and this is in connection with our automatic switching system—is that we must avoid a code which will cause disconnection of that system. Therefore, you cannot put over existing systems a new code unless that code is controlled and, of course, requires new equipment design for the code. So it is an economic question and we feel that in order to use the equipment the thing to do, where high accuracy is a must, is to provide some other type of parity check within the five unit code. As we go to newer high speed facilities our thinking is that it will be in the direction of the seven bit code.

W. A. Hunt (IBM): How often, on the average, do noise bursts occur and how long do they last on lines such as the SAGE type?

Mr. Matlack: This is practically impossible to answer. These noise bursts occur in a random fashion. For example, lightning comes along and you get a burst of high impulse noise in the line. Some switchman working on the frame accidently touches a tool against the line causing a burst. Some error rate will be specified as the result of tests underway. This will include all factors causing errors such as impulse noise.

I mentioned in the teletypewriter field we are engineering in the worst case to an error of one in 44,000 characters. As you increase the bandwidth, you obviously let in more noise. However, depending on the measures you take, you may still be able to get a very high error-free rate so far as random noise is concerned. But it is such a random occurring thing that there is no real way to say how often it will occur.

Standardization of Computer Intercommunication

H. R. J. GROSCH[†]

I AM GOING to start today by taking a little different approach to the problem of standardization. Mr. Matlack and members of the panel are concerned primarily with the specific problem of standard media, but I would like to speak, at least for a few minutes, about the philosophy of standardization in general rather than about our particular problem. What is standardization? What are the permissive functions of the American Standards Association? What, indeed, does a printed standard of the ASA do for its sponsors and for newcomers in the technical field?

Many times, in discussing this area with individuals and with organizations, I find there is considerable ignorance and even fear about the forces behind the standardization movement. I can't speak to you as an expert, although I have been on several ASA subcommittees, and I am not authorized to speak about broad policy, but you should know something about the philosophy of the standardization movement. You should know, for instance, that standardization is a means of registering good methods of achieving technical ends. Decisions in the standards committees are made by consensus. If a consensus cannot be achieved no standard is issued. Standardization is merely a recognition of this consensus. No member of the standards committee involved, be he an individual member or a society member, is obligated to follow the adopted standard in any way. There is no such obligation implied or expressed in the philosophy of standardization or in the constitution of the American Standards Association. On the contrary, mechanisms are provided to register standard designs, standard methods, so they are available for those who wish to use them.

Senior people in our field, such as Bell and IBM, often hold back because their experience is so great they don't want to have their activities restricted by the intrusion of novices. There is no chance of that happening—I repeat, *no* chance. If someone wants to invent a 13-hole paper tape they have the express permission of the ASA to do so. The dimensions and tolerances of that tape should be registered so if someone else wants to have a 13-hole tape he can find out how his predecessor did it, but there will be no pressure to abandon the 13 for two 7's.

I want to talk for a few minutes about the computer art and the way it has developed. People are talking about intercommunication between million dollar machines over thousands of miles of distance. Yet eight years ago a prime article of commerce was a punched card table of reciprocals. And with this tremendous growth has come a desire to exchange a great deal more information than was necessary in the early days. We used to trade IBM panel diagrams and things like that.

[†] Manager, Investigations; Aircraft Gas Turbine Development Dept., General Electric Co., Cincinnati, Ohio.

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But now there is a present and pressing need for the trading of mass information.

In fact, I would like to point out that Mr. Matlack is being very conservative when he talks about voice transmission and the Bell System. It is my belief that within a few years transmission of digital information is going to overwhelm the transmission of crude human voices. We are participating in a technological burst which is going to alter such things a great deal.

As the mass flow of information accelerates it is more and more important that we make a clear statement of the problems which warrant standardization and set up some kind of cooperation to tackle these problems. I think of three areas where the transmission of masses of information in business—remember, this is supposed to be one of the themes of our conference—is becoming increasingly important. First is the centralized company where information has to flow radially between the outlying sales offices and factories and the central organization. True, many of you have heard me say that there are no human beings at the center capable of listening to this information, but if we replace obsolete executives with large computing machines this becomes a practical method of running a business.

A second class of transmission of large quantities of data arises from a decentralized operation like General Electric. Here there is a flow over most of the meshes of a rather complex network. There is no single point where all information must concentrate. Requirements of band width and tape length will be different. Nevertheless, the total number of bits transmitted per day is undoubtedly much greater than in a radial system. Moreover, it is not out of the question that an outfit that wishes to decentralize authority—and that is fundamental in G.E.—may still wish to centralize information as to how that authority is being used or misused.

There is still a third and in some respects more interesting possibility than the other two. That is the serial communication of information up or down between supplier, the main business, and customer—a really enthralling possibility. We have had a slight touch of this in my operations in General Electric, where we have sent information about our new engines to computers in aircraft companies on the West Coast. We have sent the information in computer language; not, it is true, over telephone lines—the time schedule was not that demanding—but at any rate the 701's talked to each other in their own language without too much interference from human beings. We regard ourselves as the "business" and North American, say, as the "customer." This can be inverted and North American might regard us as the supplier and send the information on the combined engine and airframe on to the Air Force as a customer. The Air Force might submit it in still further automatic transmission form to "Aviation Week"!

Here are at least three imaginary situations; each of them different, as regards the way in which communications travel, and each of them capable of generating tremendous amounts of information. It is unnecessary to list all the various channels and physical media that may be involved in this intercommunication, rang from the old punched card to the fanciest multichan magnetic tape.

How many people in this audience know that ther no formal American standard for paper tape? Ther no standard issued by the ASA or any international sociation that gives the dimensions and tolerances paper stock requirements on even five-channel tape, alone the less common types. I was shocked to hear from ASA, especially when I found there was alread standard on remote and telemetered supervisory equ ment, pumping stations on pipe lines and so on, which one can pick up a telephone and dial a num and get a meter reading miles away. There is a stand on something that specialized, but not on paper ta

The hardware involved in computer intercommu cation may be divided into three classifications. Fi and most important, is the primary hardware whic capable of recognizing a signal or generating a sig Here I am referring to the type of magnetic recordi and to the lateral spacing and number of channels ac a magnetic tape. In the case of perforated tape, equivalent properties are the size and position of holes, and thickness of stock. In punched cards, I 80-column, Minicard, Remington Rand, and other t each have fixed dimensions and tolerances, and terial requirements. If this single most important is standardized it is then possible for various input output mechanisms to at least generate and rec messages.

Second, there is a hardware problem involved in *acceptability* of the signal, In many magnetic and pa tape systems, there is a built-in redundancy ch which makes certain combinations of signals which by the head of the tape unit, unacceptable to the re the electronics. One might say, standardization of mary hardware is required if the computer is to he signal, and of secondary hardware if it is to pay attent

Finally, if the message has gotten past the hardw there is the third element of agreed code. A general pose computer is perfectly willing to accept, to co phrase, standard gibberish because it is capable of tr lating that gibberish into its own language by grammed manipulation. So, if the bit code internal computing machine uses a certain set of ones and z to represent the letter "f," and if that set happens t Western Union notation for the letter "a," no harm been done providing a general purpose program is as part of the communications network to intercha "a" and "f" in the message.

The first item of business, then, is insurance tha message can be gotten into the system at all. We sho talk about tape punching mechanisms, numbers channels, and recording heads. Secondly, we should sure that the signals are acceptable to the logic of communications system. Lastly, if possible, we sho register common codes so that "a" will always be and "7" will always be "7," or so that we can prog the translation.

So much for the individual characters. Now, about the problems of semantics, the problem of doing something useful with this set of bits which was sent from computer to computer. This involves the user of the machine as well as the builder of the machine. I think many of this audience are familiar with efforts on the West Coast to standardize computer language in the broad sense of the word. First, something about motivation: many of the users of digital systems have been and will be faced with the problem of changing machines. During 1956, for instance, my group will be operating a 701 through at least April and will be beginning to use three 704's. These machines have different languages. They have rather similar character representation and identical reading equipment. But programs we have written for the 701 are not usable on the 704. And how much more difficult the situation would be if we were switching from a small IBM machine to a larger machine built by a competitor with very different philosophy.

One way to minimize the effect of a changeover is to have written your programs initially in a pseudolanguage—a pseudolanguage which both the 701 and 704, say, can translate into their own preferred language. This means that if the 701 programs were originally written in a pseudolanguage, which compiling and interpreting routines then translated into "pure 701," a different set of routines could be used to take original programs in the pseudolanguage and translate into "pure 704" with no further thought on our part. This is a very long term problem in standardization, a very difficult one, but one which may properly be given as a charge to some working committee.

It is clear we face a dynamic situation, not a static one. Grace Hopper has been talking about this for years and those who have heard her speech eight or ten times have observed trends; there are changes. There are going to be further changes, especially among those of us just now getting on the bandwagon. We must regard standardization of hardware and semantics as temporary. And we have already passed the point of optimum beginning. Our practices are already divergent in many respects. I am not trying to call for restrictive measures. Someone pushing 31-channel tape? Fine, by all means let's try it, but let's not have two different *seven*-channel systems if we can register a permissive standard that all new designers can refer to. Usually the saving in design cost to the late comer will be so great that he will willingly—I repeat, willingly—conform to the established standard.

This will help hundreds of users of large machines and thousands of users of small machines in the next years. Our industry was worth a few thousands a month ten years ago and will be worth a billion dollars a year by 1962. It is important that we move to help ourselves by using these techniques of standardization at the earliest possible moment through member societies of the JCC, in the JCC itself, in the fraternity of computer users, and through the manufacturers.

Discussion

C. Adams (Westinghouse): Would you care to pick the date on which the message volume will exceed that of TV and that of voice?

Mr. Grosch: I don't care to, but I will.

Mr. Adams: When will this information volume exceed the volume of bits transmitted by the United States mail?

Mr. Grosch: I will make a guess at the first one. As we improve the technique of TV transmission, perhaps by sending only the derivative instead of the complete image, and as integrated data processing in digital form goes up, this intersection might be as soon as four years from now.

As for the second question, one school generation, at the present rate!

M. Harper (Sperry-Rand): How efficient will your translated 701 routines be when run on the 704?

Mr. Grosch: We decided that the efficiency would be so low that it would be better to use the pseudolanguage idea and rewrite some of our 701 programs in the pseudolanguage. It is difficult to think of a method of bringing in the indexing capabilities of the 704 when translating a 701 program. Of course, the opposite would be more easily possible; one could call in for each indexing instruction a complete subroutine of conventional 701 variety; but to go the other way requires the recognition of a pretty large chunk of program.

H. Livingston (Burroughs): What rules would be used in establishing a pseudolanguage? Would the pseudolanguage apply only to the foreseeable future?

Mr. Grosch: Part of the problem is certainly caused by the unforeseeable extra capabilities of future machines; part, by the somewhat unforeseeable utilization of these machines. Look, maybe it isn't as desperate as all that. We are talking quite a bit at this meeting about business problems. The language of business is messy: it is historical, it is poorly chosen, it is extraordinarily redundant. But the total dictionary of business terms—and I mean information, not just words—is really pretty limited. I would think, for instance, that it would be much easier to generate a pseudolanguage for accounting problems than differential equations. Most of you know that there is a strong effort to generate a pseudolanguage in which the input would be algebraic, and I just can't believe that the problems of accounting require a more imaginative language than that. What those problems require is more imaginative *accountants*.

R. Gillett (NSA): Does not the lack of standardization mean that the investment in programs makes a user reluctant to change to a new computer?

Mr. Grosch: Well, as long as there is a shortage of new computers I don't suppose this is a governing item. In talking to my management about moving to bigger and better and more expensive machines I usually say that the way to get around the problem is to have a highly professional group which in the first place is willing to learn a new language, in the second place is capable of cooperating on a pseudolanguage, and in the third place, is able to change over efficiently. I suppose if the day ever comes when there are surpluses of large computing machines, and price wars between the manufacturers—that will be the day!—the quality of programming of these conventions by the manufacturers will be the deciding item in the switchover.

Mr. Schleicher: Has a good dictionary of computer terminology been compiled and, if so, where?

Mr. Grosch: There have been several glossaries. The IRE Committee on Electronic Computers had a subcommittee on nomenclature of which I was a member. Grace Hopper helped work up another. There are two or three such efforts published —one by the IRE, and one by Ed Berkeley. Again, I think the crux has been the feeling that it was restrictive. A lot of people felt that once there was a definition of "flipflop" or "programming" they were stuck. That isn't the purpose. A standard on terminology simply warns an author that he should explicitly define new words, or words he uses in a non-standard way. It would be perfectly proper to have a subcommittee of the standardization effort I am describing consolidate these efforts.

I wonder if I might mention again the word "consensus." No standard is published by the ASA unless a consensus of the members of the working committee has been reached.

Feb. 22, 1955 E. BUHLER 2,702,506

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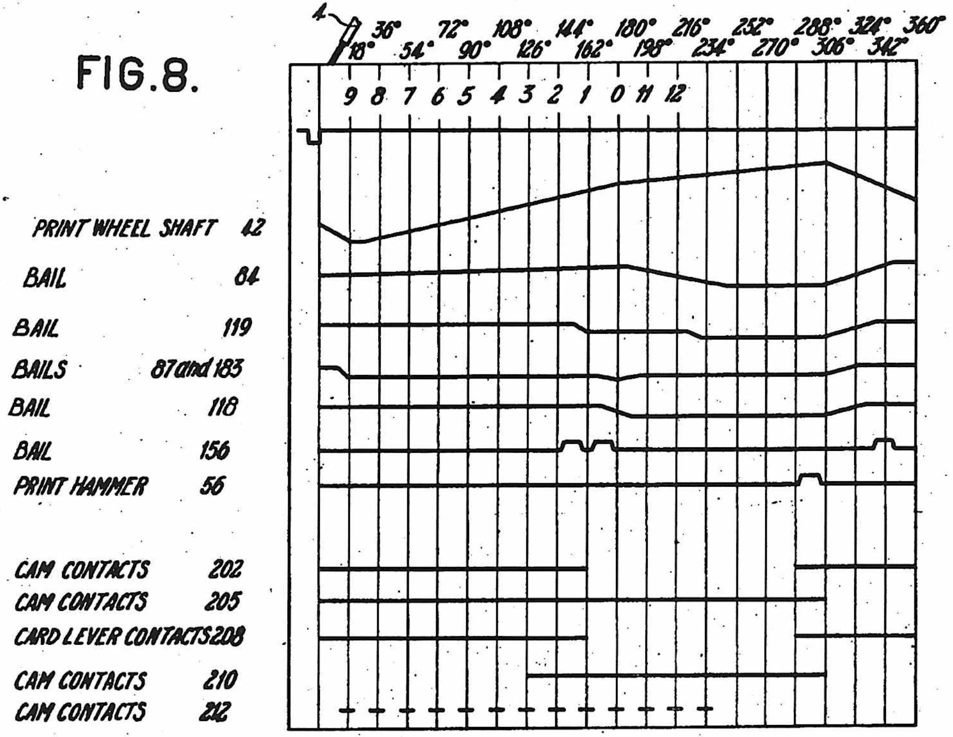
Filed Sept. 30, 1950 10 Sheets-Sheet 6

FIG. 8.



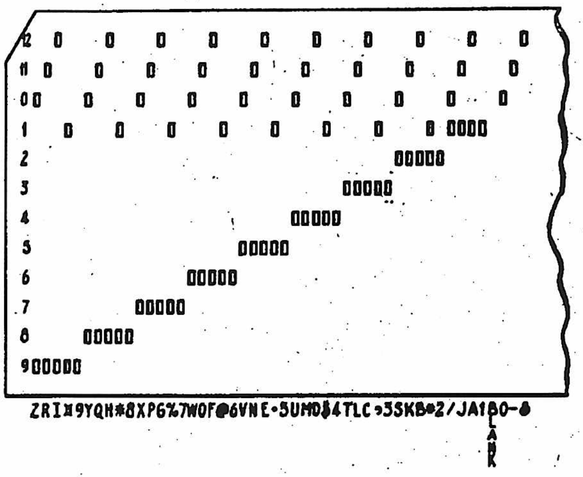
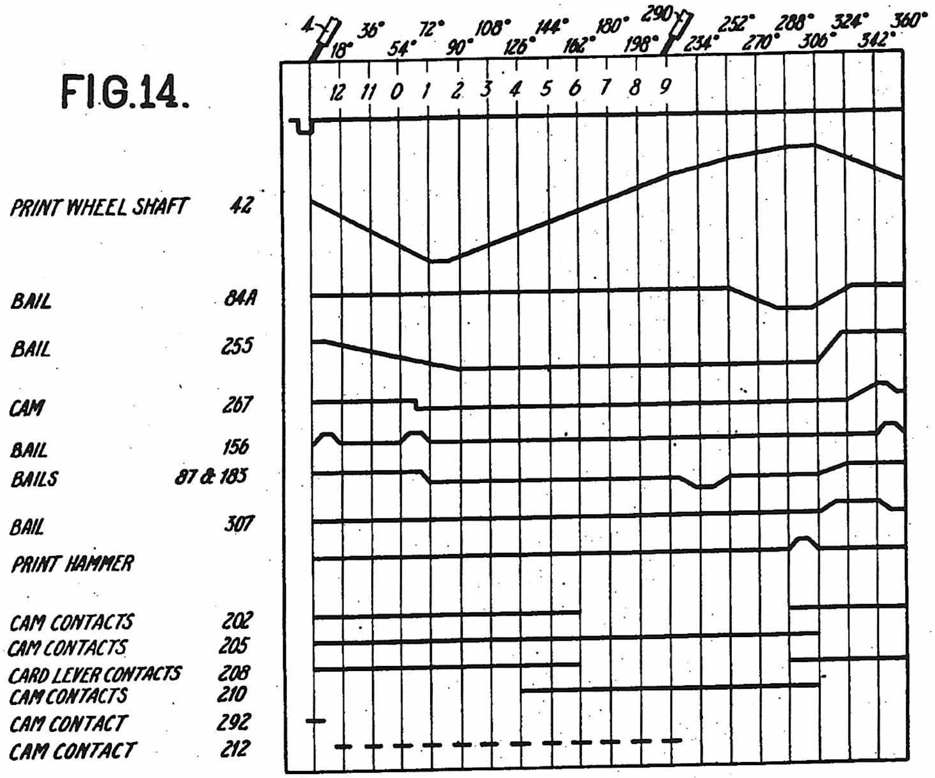


FIG. 7.

INVENTOR
Eugen Buhler

BY Ralph C. Dustin
ATTORNEY

FIG.14.



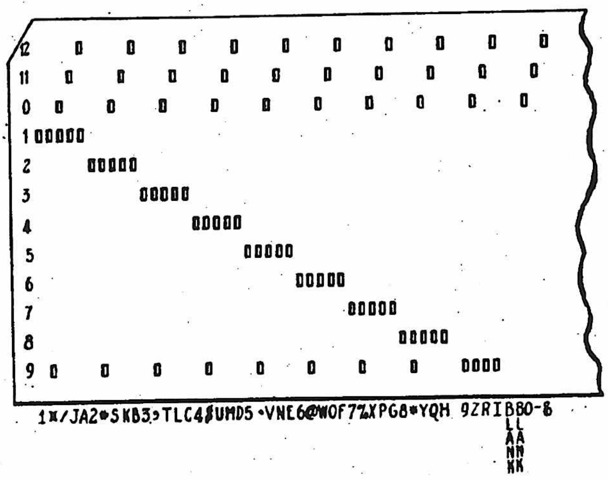
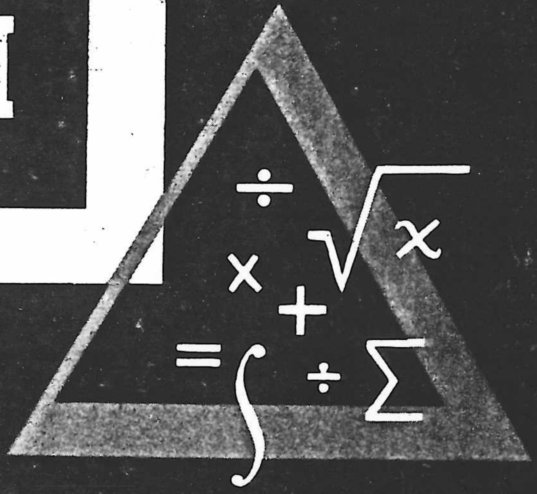


FIG.12.

INVENTOR
Eugen Buhler
BY Ralph C. Dustin
ATTORNEY

IBM



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IBM

APPLIED SCIENCE DIVISION

Technical Newsletter No. 10

October 1955

A Computation Seminar, sponsored by the International Business Machines Corporation, was held in the IBM Department of Education, Endicott, New York, from August 1 through August 4, 1955. Participating in this seminar were 67 research engineers representing computing facilities which employ IBM 650 Magnetic Drum Data Processing Machines. The formal papers of the seminar are published in this Technical Newsletter so that the authors' valuable information and experience may be shared as widely as possible.

The papers may be grouped into three general classifications. The first few papers describe different systems which have been developed and used for programming and operating the 650, including a wide variety of subroutines. The second group of papers describes methods and programs for solving various general classes of mathematical problems. The third group describes the use of the 650 in many different fields of engineering and science. Also included are descriptions of recently developed special attachments to the 650, which provide for even greater flexibility, a partial listing of subroutines used by 650 customers, and a listing of typical 650 customer applications.

The authors of these papers have very generously agreed to make available program card decks and other necessary information (flow charts, wiring diagrams, etc.) so that other 650 customers may be able to use the same procedures.

The International Business Machines Corporation wishes to express its appreciation to all those who participated in this seminar.

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optimum and a non-optimum placement of the next machine language instruction was less than 2 milliseconds. Considering these results it was decided to make multiplications and divisions convenient breaking points; that is, the subroutine would be optimized up to a multiplication and the next instruction placed so as to be optimum with respect to some other portion of the program rather than to the multiplication itself. Another device that was used to speed up the system is based on the fact that there are locations for placement of data which are optimum as far as each of the abstract instructions is concerned. Realizing this, all of the subroutines were constructed so that the optimum placement of data for one instruction was the same or nearly so as for another instruction. We call these groups of storages that are placed optimumly with respect to the system, preferred storages. They vary somewhat from one instruction to another but always include our ten result storages so that the result of one operation will be placed optimumly for any future instruction referring to it.

By the end of November the system was complete and when we came to Endicott the last of November we succeeded in checking out almost all of the program. This was early enough so that we could transfer all of our routine work to the 650 before the first machine was delivered in March.

While we were developing our system, our associates in the Missiles System Division of the company, were preparing other subroutines that would tie in with the FACS system. These subroutines were square root, logarithm, antilogarithm, sine and cosine and arc tangent. These latter subroutines were arranged so that they could be added to or left off of the rest of the system as desired.

In using the FACS system for the last five months we have reached the following conclusions:

1. The command list is a well balanced one and has proven to be easy to use.
2. In training new personnel no difficulty was encountered in teaching the system except for one of the branch instructions (the branch on relative zero instruction in which ease of coding was sacrificed for speed)
3. 80 to 90% of our work now utilizes the FACS system with no compulsion placed upon our programmers to do so.
4. We do not intend to do any further development work for the 650 because of the imminence of our 704. However, if this were not so the only further development that we would consider in regard to the FACS system is to recode portions of it in order to increase speed and/or compactness.

A GENERAL UTILITY SYSTEM FOR THE IBM TYPE 650

The Mathematical Analysis Section
Missile Systems Division
Lockheed Aircraft Corporation

THE MATERIAL CONTAINED HEREIN SHOULD ALLOW EFFECTIVE AND EFFICIENT USAGE OF THE TYPE 650 WITHOUT DUPLICATION OF DEVELOPMENT OR MISDIRECTION OF PRINCIPLES. THIS COLLECTION OF ROUTINES AND METHODS REPRESENTS AN OVERALL PHILOSOPHY OF OPERATION WHICH HAS HAD GOOD SUCCESS IN ACTUAL OPERATION IN AN ENGINEERING AND SCIENTIFIC APPLICATION. THESE ROUTINES HAVE BEEN USED IN MUCH THEIR PRESENT FORM ON 650S NUMBER 10 AND 37 AND WILL BE USED ON A THIRD MACHINE DELIVERED AT THE END OF JULY 1955.

ALL OF THESE ROUTINES ARE OF THE TYPE COMMONLY KNOWN AS UTILITY . THIS MEANS THAT THEY ARE APPLICABLE TO MOST PHASES OF ENGINEERING OR SCIENTIFIC COMPUTING. MANY ARE EQUALLY SUITABLE FOR BUSINESS APPLICATIONS. THE STANDARD CARD FORM[1] AND CONTROL PANELS DESCRIBED ARE VITAL TO INTEGRATED OPERATION OF THIS SYSTEM. INITIAL ADOPTION OF THIS SYSTEM FOR LATER MODIFICATION SHOULD PROVE TO BE A GREAT HELP TO NEW INSTALLATIONS.

THE DEVELOPMENT OF THE FLOATING DECIMAL ABSTRACTION WAS DONE JOINTLY BY THE MATHEMATICAL ANALYSIS DEPARTMENTS OF BOTH THE GEORGIA DIVISION AND THE MISSILE SYSTEMS DIVISION OF LOCKHEED. THE ARITHMETIC PORTION IS DUE TO GEORGIA AND THE SUBROUTINE PORTION TO MSD. LATER DEVELOPMENTS WERE MADE AT MSD IN PACKAGING THE SYSTEM AND PUTTING TRACING UNDER CONTROL OF THE CONSOLE. THEREFORE FACS AT GEORGIA AND FLAIR AT MSD ARE SOMEWHAT DIFFERENT IN OPERATION. FOR THIS REASON THE ENTIRE SYSTEM IS PRESENTED HERE AS MSD USES IT - DESPITE POSSIBLE DUPLICATION IN CERTAIN RESPECTS OF THE WORK OF THE GEORGIA PEOPLE.

IT MAY BE NOTICED THAT THE MAJORITY OF THESE ROUTINES ARE NOT WHAT ARE COMMONLY TERMED ELEGANT. EXCESSIVE POLISHING WOULD NOT GAIN US VERY MUCH IN MACHINE SPEED AND WOULD CERTAINLY LOSE EFFORT THAT HAD BETTER BE PUT TO DOING USEFUL COMPUTING WORK. THESE ROUTINES WORK AND THEY WORK SUCCESSFULLY. THE MOST IMPORTANT THING IS THAT THEY ARE AVAILABLE TO ANYONE FOR IMMEDIATE USE. CREDITS FOR THE VARIOUS ITEMS ARE AS FOLLOWS

ARITHMETIC FLAIR-FACS INCLUDING TRACE	GEORGIA MATH ANALYSIS DEPT.
FLAIR COMPILATION AND EDITING	ED DODGE
FLAIR SUB-ROUTINE SQUARE ROOT	ROBERT BEMER
FLAIR SUB-ROUTINE LOG-ANTILOG	IRENE BROWN AND JACK ANTCHAGNO
FLAIR SUB-ROUTINE SINE-COSINE	ALBERT PODVIN
FLAIR SUB-ROUTINE ARCTANGENT	CHARLES WIMBERLEY
MACHINE LANGUAGE TRACE USABLE WITH FLAIR	RAY CIANCI
REGIONAL ASSEMBLY ROUTINE	RAY CIANCI
PUNCH DRUM FROM α TO β	DON JACKSON
PUNCH β EIGHTHS OF THE DRUM	DON JACKSON
TYPE 407 UTILITY PANEL	RICHARD MIDDLETON
TYPE 533 UTILITY PANEL	RICHARD MIDDLETON
FIVE-FIELD LOAD ROUTINE AND CARD FORM	ROBERT BEMER
FLAIR TO FIXED DECIMAL ROUTINE	ROBERT BEMER AND ELAINE GATTEN

1. Other companies may temporarily order the card form from IBM in San Jose, California, if they so desire.

FIVE-FIELD LOAD ROUTINE

THIS TYPE 650 LOADING ROUTINE IS DESIGNED TO LOAD FIVE WORDS PER CARD IN RANDOM ADDRESSES. THE FORMAT IS THAT LABELED NUMBER 1 ON THE STANDARD 650 CARD FORM. A FIVE-WORD CARD WAS CHOSEN ARBITRARILY TO EFFECT THE MOST EFFICIENT LOADING WITH A MINIMUM OF RESTRICTIONS. THIS ROUTINE IS BELIEVED TO BE THE SIMPLEST IN OPERATION AND CAN LOAD THE ENTIRE MEMORY IN 2 MINUTES.

A LOAD-IDENTIFICATION CARD CONTAINING THE SIX INSTRUCTIONS OF THE LOADING ROUTINE MUST PREFACE ANY ROUTINE. 8000 IS SET TO 70 1901 XXXX. DEPRESS THE COMPUTOR RESET AND PROGRAM START BUTTONS. PLACE THE ROUTINE IN THE READ HOPPER OF THE TYPE 533 AND DEPRESS THE READ START BUTTON. THE LOAD-IDENTIFICATION CARD IS READ UNDER THE CONTROL OF 8000 AND THE NEXT INSTRUCTION WILL BE TAKEN FROM 1901. THIS INSTRUCTION IS ONE OF THOSE READ IN FROM THE LOAD-HUB CARD AND CALLS FOR THE READING OF THE FIRST FIVE-FIELD LOADING CARD. THE NEXT INSTRUCTION IS TAKEN FROM 1902 AND RANDOM LOADING PROCEEDS BY SUCCESSIVE LOAD AND STORE DISTRIBUTOR COMMANDS. THE CYCLICAL PATTERN OF LOADING IS EVIDENT BY TRACING THE INSTRUCTIONS. THE O AND I PARTS OF THE STORE DISTRIBUTOR COMMANDS ARE EMITTED ON THE TYPE 533 PANEL. THE DIAGRAM OF THE TYPE 533 UTILITY PANEL SHOWS THIS WIRING IN THE C READ POSITION.

THE ONLY RESTRICTION OF THIS SYSTEM IS THAT THE LAST INSTRUCTION LOADED IN MEMORY IS THE FIRST TO BE OBEYED IN THE ROUTINE. THIS IS ACCOMPLISHED BY A 12 PUNCH IN THE UNITS POSITION OF THE A PART OF ANY OF THE FIVE FIELDS. THIS PUNCH TRANSFERS A CO-SELECTOR WHICH REPLACES THE I PART OF THE STORE DISTRIBUTOR COMMAND BY THE D PART. THUS THE LAST INSTRUCTION IS LOADED INTO ITS ADDRESS AND THE LOAD ROUTINE IS DISRUPTED SO THAT THIS INSTRUCTION IS THE NEXT TO BE OBEYED. THIS AUTOMATICALLY STARTS THE PROGRAM UPON COMPLETION OF LOADING. TO RESTART THE PROGRAM ONCE IT HAS BEEN LOADED IT IS NECESSARY TO USE ONLY THE LOAD-IDENTIFICATION CARD AND THE CARD CONTAINING THAT FIRST INSTRUCTION TO BE OBEYED.

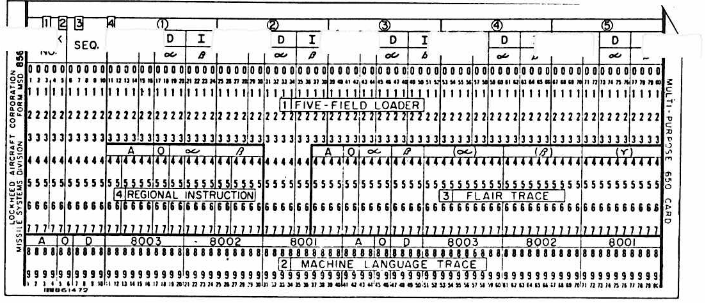
LOAD-IDENTIFICATION CARD		12-PUNCH IN COLUMN 1	
WORD 1	70 1951 1902+	WORD 5	69 1958 1957+
WORD 2	69 1952 1951+	WORD 6	69 1960 1959+
WORD 3	69 1954 1953+	WORD 7	10 8001 1965+
WORD 4	69 1956 1955+	WORD 8	35 0001 1966+

NOTE --- WORDS 1 THRU 8 ENTER ADDRESSES 1901 TO 1908 RESPECTIVELY. WORDS 7 AND 8 IN STORAGES 1907 AND 1908 ARE USED IN FLAIR. THEY MUST BE ON THE LOAD-IDENTIFICATION CARD TO PRESERVE THEM IN CASE THE LOAD-IDENTIFICATION CARD IS USED AFTER FLAIR IS ALREADY ON THE DRUM.

A O D AND I ARE READ FROM EACH FIELD OF THE FIVE-FIELD LOAD CARD SO THAT STORAGES 1951 THRU 1960 ARE FILLED AS FOLLOWS

A	O	D	I	A	O	D	I	A	O	D	I
1951	24	A_1	1903	1955	24	A_3	1905	1959	24	A_5	1901
1952	O_1	D_1	I_1	1956	O_3	D_3	I_3	1960	O_5	D_5	I_5
1953	24	A_2	1904	1957	24	A_4	1906				
1954	O_2	D_2	I_2	1958	O_4	D_4	I_4				

SINCE THE I PART OF 8000 IS NOT USED IN THIS ROUTINE THESE FOUR POSITIONS MAY BE USED AS EFFECTIVE SENSE SWITCHES BY SETTING THEM AT 8 OR 9 AND INTERROGATING 8000 DURING THE ROUTINE. 8000 MAY ALSO BE SET EITHER + OR - AND INTERROGATED FOR DECISION. DO NOT ALTER THE SETTING OF 8000 SWITCHES WITHOUT FIRST DEPRESSING THE PROGRAM STOP BUTTON.



DECK 033.01 PUNCH β EIGHTHS OF THE DRUM

THIS ROUTINE PUNCHES β EIGHTHS OF THE DRUM IN SUCH A FASHION THAT THE LIST IS REPRESENTATIVE OF DRUM LAYOUT. β MAY VARY FROM 1 TO 8. PUNCHING STARTS WITH THE CONTENTS OF α. TO OPERATE THIS ROUTINE

1. SET 8000 TO 70 1901 XXXX
2. PUT LOAD-IDENTIFICATION CARD IN FRONT AND LOAD DECK 033.01
3. BEFORE DEPRESSING END-OF-FILE CHANGE CONSOLE TO 00 α β
4. DEPRESS END-OF-FILE BUTTON

A	O	D	I	A	O	D	I	A	O	D	I
0997	01	8000	8000	0912	69	8003	0913	0913	23	0991	0914
0914	16	8001	0915	0915	15	0990	0916	0916	10	0992	8002
0917	24	0978	0918	0918	22	0977	0919	0919	15	8003	8002
0920	24	0980	0921	0921	22	0979	0919	0923	24	0982	0924
0924	22	0981	0919	0926	24	0984	0927	0927	22	0983	0919
0929	24	0986	0930	0930	22	0985	0931	0937	10	8001	0938
0938	35	0008	0939	0939	44	0946	0940	0940	65	0991	0941
0941	16	0994	0942	0942	45	0943	0997	0943	20	0991	0944
0944	65	0996	0945	0945	15	0995	0916	0946	65	0995	0916
0990	69	0000	0917	0992	00	0050	0003	0993	00	0199	0012
0994	00	0000	0001	0996	00	0200	0000	0931	71	0977	0932
0932	16	0993	0933	0933	20	0995	0934	0934	30	0004	0936
0936	60	8002	0937	0911Y	65	8000	0912				

PUNCHING IS IN THE FIVE-FIELD LOADER FORM FROM THE C PUNCH OF THE TYPE 533 UTILITY PANEL.

DECK 033.02 PUNCH DRUM FROM α TO β

OPERATION INSTRUCTIONS FOR THIS ROUTINE ARE THE SAME AS FOR DECK 033.01. PUNCHING IS ALSO ON THE FIVE-FIELD LOADER FORM BUT SEQUENTIAL ON EACH CARD.

A	O	D	I	A	O	D	I	A	O	D	I
1911	69	1946	1912	1920	24	1930	1921	1939	46	1940	1941
1912	35	0004	1913	1921	21	1929	1945	1940	10	8001	1942
1913	22	1910	1914	1922	24	1932	1923	1942	10	1949	8003
1914	35	0002	1943	1923	21	1931	1945	1941	01	0000	0000
1943	60	8003	1915	1924	24	1934	1925	1945	10	8002	8003
1915	35	0004	1916	1925	21	1933	1945	1946	69	0000	0000
1916	15	1947	1917	1926	24	1936	1944	1947	00	0001	0002
1917	10	1948	8003	1944	21	1935	1937	1948	69	0000	1918
1918	24	1928	1919	1937	71	1927	1938	1949	00	0000	9992
1919	21	1927	1945	1938	11	1910	1939	1900Y	67	8000	1911

DECK 033.05 - MACHINE LANGUAGE TRACING ROUTINE

ALL MACHINE LANGUAGE COMMANDS ARE ANALYZED IN OPERATIONAL ORDER. THE LOCATION ADDRESS - OPERATION CODE - DATA ADDRESS AND THE THEORETICAL CONTENTS OF 8003-8002 AND 8001 ARE PUNCHED. TWO SUCH INSTRUCTIONS ARE PUNCHED PER CARD. LISTING OF THESE CARDS ENABLES STEP-WISE FOLLOWING OF THE RESULTS OF AN ACTUAL PROGRAM. THE CARD FORMAT IS THAT LABELED NUMBER 2 ON THE STANDARD 650 CARD FORM.

THE TRACING ROUTINE MAY BE STORED IN ANY TWO ADJACENT DRUM BANDS. THE ATTACHED CODING IS LOCATED FROM 1200 TO 1299. THE ROUTINE MAY BE EITHER PLACED ON THE DRUM PREVIOUSLY OR ACCOMPANY THE PROGRAM TO BE TRACED. IN EITHER CASE A TRACING CONTROL CARD MUST BE INSERTED IN THE PROGRAM DECK BEYOND THE LOADING OF THAT INSTRUCTION WITH WHICH TRACING BEGINS. IF THE TRACING CONTROL CARD IS LOADED SEPARATELY A_1 CANNOT BE 800X NOR CAN THE ORIGINAL INSTRUCTION IN A_1 CONTAIN 800X. TRACING MAY START AT ANY PLACE ALONG THE PROGRAM. THE PROGRAM CONTINUES AT MACHINE SPEED WITHOUT TRACING AFTER THE LAST ADDRESS TRACED IS REACHED. SYMBOLS FOR THIS ROUTINE ARE

A_1 - ADDRESS OF FIRST INSTRUCTION TO BE TRACED.
I_1 - THE INSTRUCTION AT ADDRESS A_1.
α_1 - I_1 IS SENT TO ADDRESS α_1. USUALLY $\alpha_1 = A_1$ HOWEVER IF $\alpha_1 \neq A_1$ TRACING WILL BEGIN WHENEVER THE ADDRESS A_1 IS AGAIN INSTRUCTED. THIS FEATURE FACILITATES LOOP TRACING.
A_n - ADDRESS OF LAST INSTRUCTION TO BE TRACED.

THE TRACING CONTROL CARD IS A FIVE-FIELD LOADER. IT SHOULD CONTAIN THE FOLLOWING THREE WORDS FOR USING ONLY MACHINE LANGUAGE TRACE.

A	O	D	I
1298	$\longleftarrow$	I_1	$\longrightarrow$

A	O	D	I
1299	65	α_1	A_n

A	O	D	I
A_1	24	1284	1265

IT SHOULD CONTAIN THE FOLLOWING TWO WORDS WHEN TRACING IS TO BEGIN IN FLAIR AND CONTINUE ALTERNATELY IN MACHINE LANGUAGE AND FLAIR.

A	O	D	I
1290	69	8000	1243

A	O	D	I
1677	16	1834	1239

IF TRACING IS TO BEGIN WITH MACHINE LANGUAGE AND ALTERNATE WITH FLAIR ALL FIVE OF THESE WORDS MUST BE ON THE TRACING CONTROL CARD WITH A_n = 1735. COMPOSITE TRACING OF BOTH MACHINE LANGUAGE AND FLAIR COMMANDS IS UNDER THE CONTROL OF THE HUNDREDS POSITION OF 8000D. WHEN 8000 READS 70 1901 XXXX TRACING WILL BE OPERATIVE IN MACHINE LANGUAGE UNTIL THE PROGRAM GOES TO FLAIR. TRACING WILL NOT RESUME UPON RETURN TO MACHINE LANGUAGE. WHEN 8000 READS 70 1801 XXXX TRACING WILL CONTINUE THRU BOTH M. L. AND FLAIR.

```
 A     O   D    I          A     O   D    I          A     O   D    I
1200  69 1249 1201        1229  22 1233 1218        1259  00 1227 1215
1201  23 1285 1202        1230  60 1282 1231        1260  71 1277 1237
1202  60 1282 1242        1231  15 1283 1232        1261  65 1254 8002
1203  19 1283 1204        1232  69 1284 1233        1262  99 9999 9999-
1204  46 1207 1205        1233  65 0000 1234        1265  20 1283 1266
1205  60 1282 1206        1234  24 1249 1235        1266  21 1282 1267
1206  15 1283 1211        1235  65 1233 1236        1267  65 1299 1268
1207  60 1283 1208        1236  30 0004 1287        1268  69 1258 1269
1208  19 1262 1209        1237  69 1221 1238        1269  23 1258 1270
1209  15 1282 1210        1238  24 1218 1240        1270  69 1273 1271
1210  14 1262 1211        1239  20 1249 1248        1271  22 1273 1272
1211  21 1278 1212        1240  69 1249 1241        1272  69 1298 1273
1212  20 1279 1213        1241  24 1285 1202        1273  24 0000 1274
```

```
 A     O   D    I          A     O   D    I          A     O   D    I
1213  69 1284 1214        1242  45 1203 1205        1274  24 1249 1275
1214  24 1280 1285        1243  97 1244 1245        1275  30 0004 1276
1215  24 1284 1216        1244  45 1293 1291        1276  20 1277 1287
1216  20 1283 1217        1245  65 1247 1246        1286  88 8080 0000
1217  21 1282 1225        1246  20 1218 1293        1287  69 1249 1288
1218  71 1277 1219        1247  00 0000 1237        1288  23 1281 1289
1219  69 1220 1222        1248  24 1283 1236        1289  16 1258 1290
1220  69 1221 1222        1250  39 9000 0000        1290  45 1293 1291
1221  71 1277 1219        1251  49 9000 0000        1291  65 1260 1292
1222  24 1218 1223        1252  89 9000 0000        1292  20 1218 1293
1223  69 1281 1224        1253  99 9000 0000        1293  65 1261 1294
1224  24 1277 1230        1254  65 1259 1200        1294  69 1249 1295
1225  65 1249 1226        1255  65 1259 1296        1295  84 1254 8002
1226  35 0004 1228        1256  65 1259 1200        1296  69 1249 1297
1227  65 1249 1228        1257  65 1259 1296        1297  22 1285 1201
1228  69 1233 1229        1258  00 0065 1735
```

DECK 033.06 - REGIONAL ASSEMBLY ROUTINE

REGIONAL CODING IS DESIRABLE FOR ABSTRACT SYSTEMS. INDEXED REGIONAL ADDRESSES ARE ASSIGNED WHICH CAN BE CONVENIENTLY CONVERTED TO MACHINE ADDRESSES. LONG PROGRAMS MAY BE BROKEN INTO SECTIONS WHICH MAY BE CODED CONCURRENTLY AND SEQUENTIALLY AS IF STARTING AT ADDRESS 0000. EACH SECTION IS ASSIGNED TO TRUE DRUM ADDRESSES WITH THE ASSEMBLY ROUTINE WHEN THE PROGRAMMING IS COMPLETED. C2 0352 IS AN EXAMPLE OF A REGIONALLY CODED ADDRESS. C2 IS THE ADDRESS INDEX AND 0352 IS THE ADDRESS WITHIN THE C2 REGION. ALPHA-NUMERIC INDICES FROM A0-A9 TO H0-H9 ARE ALLOWABLE.

ONE REGIONAL INSTRUCTION IS PUNCHED PER CARD. THE FORMAT IS NUMBER 4 OF THE STANDARD 650 CARD FORM. THE LOCATIONS OF REGIONAL INSTRUCTIONS AND THE REGIONS THEMSELVES DO NOT HAVE TO BE SEQUENTIALLY ORDERED. A DUMMY INSTRUCTION WITH THE INDEX ADDRESS I0 MUST FOLLOW THE LAST INSTRUCTION OF THE LAST REGION TO BE ASSEMBLED.

RELOCATION OF ANY INDEXED ADDRESS TO THE TRUE DRUM ADDRESS IS ACCOMPLISHED BY SPECIFYING THE INCREMENT BY WHICH THE ADDRESS PART IS TO BE ADJUSTED AND THE LAST INDEXED INSTRUCTION TO BE SO ADJUSTED. THE ASSEMBLY ROUTINE WILL PUNCH THE DESIRED ASSEMBLED PROGRAM FROM THE C POSITION OF THE TYPE 533 UTILITY PANEL ONTO THE STANDARD FIVE-FIELD LOAD CARD.

INSERT ADDITIONAL REGIONAL INSTRUCTIONS INTO A COMPLETED REGION BY ADDRESSING AS MANY AS ARE NEEDED WITH THE SAME ADDRESS AS THE INSTRUCTION THEY FOLLOW. PLACE THEM IN THE PROGRAM DECK IN THIS ORDER. CONTROL CARD INFORMATION MUST BE ADJUSTED ACCORDINGLY. DELETION IS COMPARABLE TO INSERTION EXCEPT THAT THE UNDESIRED INSTRUCTION CARDS ARE REMOVED. THESE ALTERATIONS AND EACH REGIONAL INDEX USED MUST BE REPRESENTED WITH CONTROL INFORMATION. CONTROL WORDS ARE LOADED ON FIVE-FIELD LOADERS IN SEQUENTIAL ADDRESSES STARTING WITH 1000. AN EXAMPLE OF AN ASSEMBLY CONTROL CARD IS

```
 A    O  D    I           A    O  D    I           A    O  D    I
1000  B2 0315 0100       1001  B5 0106 0500       1002  D3 0021 0620 ETC.
```

O IS THE ALPHA-NUMERIC ADDRESS INDEX OF THE REGION
D IS THE LAST REGIONALLY INDEXED ADDRESS OF THAT REGION
I IS THE INCREMENT TO BE ADDED TO ALL ADDRESSES IN THAT REGION

REGIONAL ASSEMBLY ROUTINE — CONTINUED

CARDS ARE PLACED IN THE TYPE 533 IN THE FOLLOWING ORDER
1. LOAD-IDENTIFICATION CARD
2. DECK 033.06 - REGIONAL ASSEMBLY ROUTINE
3. ASSEMBLY CONTROL CARDS AS NEEDED
4. STARTER CARD - 0500Y 65 0807 0501 IN FIELD 1.
5. REGIONALLY-CODED PROGRAM - ONE INSTRUCTION PER CARD

```
 A     O   D    I           A     O   D    I           A     O   D    I
0500  65 0807 0501         0551  69 8003 0552         0601  65 0801 0602
0501  35 0001 0502         0552  23 0822 0553         0602  10 0800 0603
0502  20 0817 0503         0553  65 0811 0554         0603  21 0783 0604
0503  20 0818 0504         0554  35 0004 0555         0604  20 0784 0607
0504  21 0819 0505         0555  15 0401 0556         0605  65 0801 0606
0505  65 0803 0506         0556  15 0819 0557         0606  10 0800 0607
0506  20 0559 0508         0557  69 8003 0558         0607  21 0785 0608
0508  70 0401 0509         0558  22 0820 0559         0608  20 0786 0609
0509  65 0401 0510         0559  24 0777 0560         0609  71 0777 0610
0510  35 0002 0511         0560  65 0559 0561         0610  65 0803 0611
0511  21 0816 0512         0561  15 0806 0562         0611  20 0559 0528
0512  30 0001 0513         0562  69 0570 0563         0615  65 0559 0616
0513  11 0807 0514         0563  22 0570 0564         0616  16 0803 0617
0514  46 0515 0615         0564  65 0405 0565         0617  45 0618 0641
0515  65 0817 0516         0565  46 0566 0568         0618  16 0802 0619
0516  16 0816 0517         0566  66 0821 0567         0619  45 0620 0624
0517  45 0580 0518         0567  16 0822 0642         0620  16 0802 0621
0518  65 0818 0519         0568  65 0821 0569         0621  45 0622 0628
0519  16 0401 0520         0569  15 0822 0642         0622  16 0802 0623
0520  45 0521 0525         0570  20 0778 0571         0623  45 0636 0632
0521  46 0522 0641         0571  65 0570 0572         0624  65 0801 0625
0522  24 0818 0523         0572  16 0804 0573         0625  10 0800 0626
0523  65 0802 0524         0573  45 0574 0577         0626  21 0779 0627
0524  21 0819 0528         0574  15 0805 0575         0627  20 0780 0630
0525  65 0819 0526         0575  69 0559 0576         0628  65 0801 0629
0526  15 0806 0527         0576  22 0559 0508         0629  10 0800 0630
0527  20 0819 0528         0577  71 0777 0578         0630  21 0781 0631
0528  65 0808 0529         0578  65 0803 0579         0631  20 0782 0634
0529  69 0401 0530         0579  20 0559 0508         0632  65 0801 0633
0530  84 1000 8002         0580  24 0817 0581         0633  10 0800 0634
0531  69 8003 0532         0581  69 0401 0582         0634  21 0783 0635
0532  23 0811 0533         0582  24 0818 0583         0635  20 0784 0638
0533  65 0809 0534         0583  65 0559 0584         0636  65 0801 0637
0534  69 0402 0530         0584  21 0819 0585         0637  10 0800 0638
0600  20 0782 0603         0585  16 0803 0586         0638  21 0785 0639
0536  69 8003 0537         0586  45 0587 0528         0639  20 0786 0640
0537  23 0812 0538         0587  16 0802 0588         0640  71 0777 0641
0538  65 0810 0539         0588  45 0589 0593         0641  01 0000 0500
0539  69 0403 0530         0589  16 0802 0590         0642  15 0404 0570
0810  65 1000 0541         0590  45 0591 0597         0800  00 1960 0000
0541  69 8003 0542         0591  16 0802 0592         0801  99 9999 9999
0542  23 0813 0543         0592  45 0605 0601         0802  00 0002 0000
0543  65 0812 0544         0593  65 0801 0594         0803  24 0777 0560
0544  35 0004 0545         0594  10 0800 0595         0804  20 0786 0571
0545  15 0402 0546         0595  21 0779 0596         0805  20 0787 0571
0546  69 8003 0547         0596  20 0780 0599         0806  00 0001 0000
0547  22 0821 0548         0597  65 0801 0598         0807  00 0000 0009
0548  65 0403 0549         0598  10 0800 0599         0808  65 1000 0531
0549  30 0004 0550         0599  21 0781 0600         0809  65 1000 0536
0550  15 0813 0551
```

DECK 033.18 FLAIR TO FIXED DECIMAL ROUTINE

THIS ROUTINE TAKES A DECK OF LOAD HUB CARDS CONTAINING EIGHT FLAIR NUMBERS OF THE FORM PP .XXXXXXXX AND CONVERTS THEM TO NINE-DIGIT FIXED DECIMAL NUMBERS. THE POSITIONS OF THE DECIMALS ARE DETERMINED BY A LOAD HUB CONTROL CARD WHICH ALSO CONTAINS THE DECK NUMBER.

THE FIRST FIELD	AAAAA 000 5B
THE SECOND THROUGH EIGHTH FIELDS	0000 0000 5B

WHERE
AAAAA IS THE DECK NUMBER
B IS THE NUMBER OF WHOLE NUMBERS IN A NINE-DIGIT FIELD

THE DECK IS PLACED INTO THE TYPE 533 IN THE FOLLOWING ORDER.
1. LOAD-IDENTIFICATION CARD
2. DECK 033.18
3. LOAD HUB CONTROL CARD
4. LOAD HUB DETAIL CARDS

THE DECK NUMBER IS SPLIT OFF FROM THE FIRST FIELD AND STORED IN 0077

```
 A     O   D    I           A     O   D    I           A     O   D    I
0039  70 0042 0042         0017  11 8003 0025         0095  21 0001 0015
0042  60 0001 0011         0025  24 0077 0089
0011  30 0002 0017         0089  35 0002 0095
```

FIELDS ONE THROUGH EIGHT ON THE DETAIL CARDS ARE CONVERTED TO FIXED DECIMAL AS SPECIFIED AND STORED IN 0078 THROUGH 0085 RESPECTIVELY.

```
 A     O   D    I           A     O   D    I           A     O   D    I
0015  70 0064 0064         0062  20 0067 0070         0021  16 0024 0030
0064  65 0067 0071         0070  16 0073 8002         0030  20 0033 0036
0071  15 0074 0029         0073  00 0050 0050         0036  65 0040 0009
0067  65 0050 0063         0013  18 0072 0027         0088  65 0091 0096
0061  65 0050 0063         0027  35 0004 0037         0096  16 0033 0038
0074  00 0001 0000         0037  46 0073 0041         0038  45 0064 0050
0029  20 0047 8002         0044  31 0001 0033         0050  69 0061 0014
0063  35 0002 0069         0041  15 0044 0049         0014  24 0067 0020
0069  21 0072 0075         0049  20 0009 0012         0020  71 0077 0015—PCH
0075  20 0040 0094         0012  65 0067 0021         0091  20 0085 0088
0094  65 0047 0062         0024  44 9972 9975
```

PUNCHING FOR THIS ROUTINE IS NOT ON THE TYPE 533 UTILITY PANEL

TYPE 407 UTILITY PANEL

THIS PANEL WILL LIST THE FOUR TYPES OF CARDS WHOSE FORMATS ARE ON THE STANDARD 650 CARD FORM. PRINTING OF THE SELECTED FORM AND APPROPRIATE HEADING IS AUTOMATIC WITH THE 12 PUNCH IN COLUMN 3 5 7 OR 11. ALWAYS TAKE A FINAL TOTAL BEFORE PRINTING. PREFACE LIST DECKS BY A BLANK CARD. THIS AUTOMATICALLY CAUSES A SKIP TO THE NEXT PAGE AND HEADS BEFORE PRINTING. PRINTING IS BASICALLY 50-10. THIS IS CONVENIENT FOR PRINTING DRUM PUNCH-OUT IN DRUM FORMAT. THE FIVE-FIELD LOADERS LIST WITH α AND β IN THE HEADING IF ALTERATION SWITCH 1 IS NORMAL. THE HEADING CONTAINS THE NORMAL D AND I IF THIS SWITCH IS TRANSFERRED.

THE LOCKHEED 407S FOR MATHEMATICAL WORK HAVE SPECIAL TYPE WHEELS AS FOLLOWS

4-8	α	3-8	+	0-1	∫
0-4-8	β	0-3-8	ω	12	γ
11-4-8	Σ	11-3-8	ρ		
12-4-8	Δ	12-3-8	•		

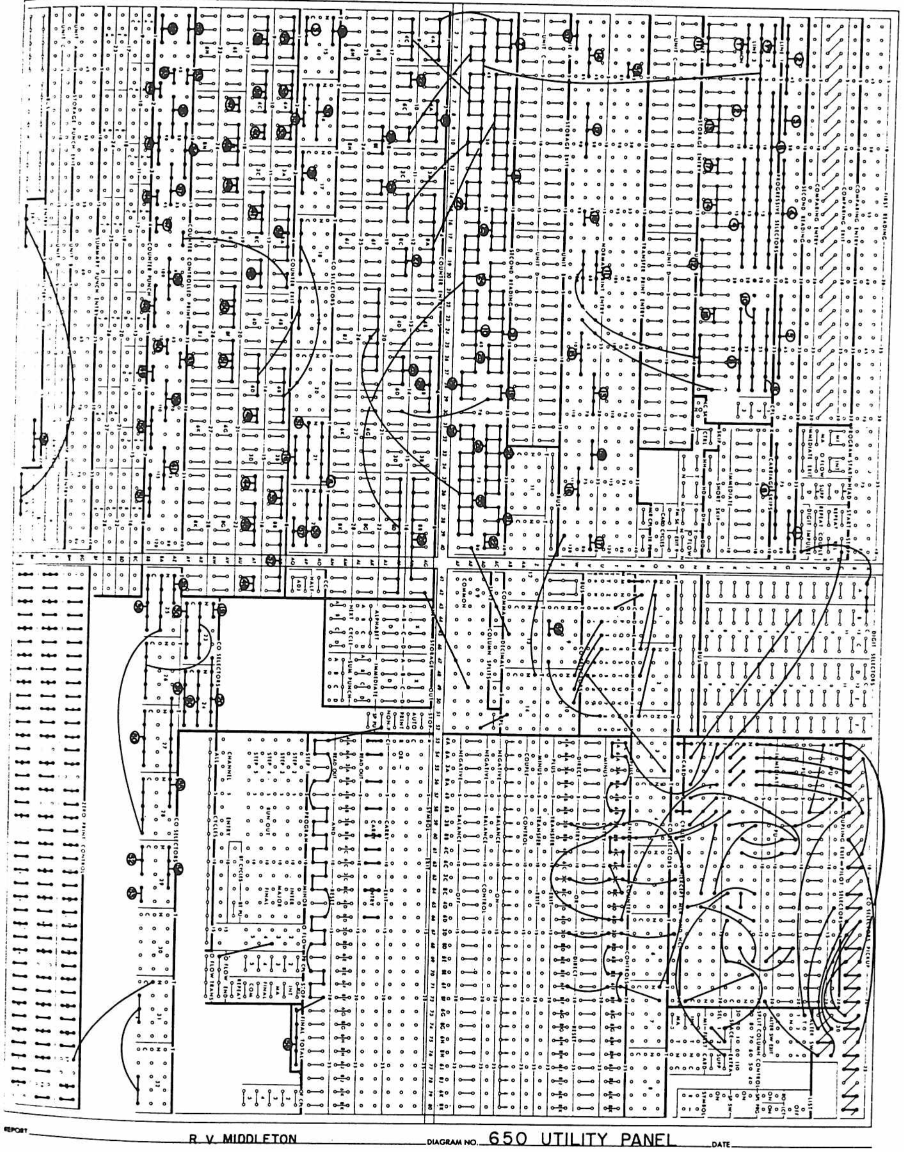
WIRING FOR THIS PANEL IS SHOWN ON A 407 BOARD DIAGRAM WHERE CONVENIENT. OTHER WIRING IS LISTED BELOW BY TERMINALS ACCORDING TO THE DIAGRAM INDEX.

A59- I30
A63-AC52
A67- C55
A78- J30
D57- C10
E33- N64
E34- J55
F41-AG32
G65-AP79
G73-AW68
I58- S68
K30- B75
K53-AQ67
K57- E11
L72- X27
M05- V24
M06- V25
N42-BK18
N43- E56
O42-BK15
O43- E53
O46-BK16
O47- C38
O48- E54
O50-BK17
O51- E55
P66- W06
P67- Z47
P68- L10
P69- L11
Q48- R54
Q49- R55
Q51- R56
Q52- R59
Q53- R57
Q54- R58
R37- G64
R43- R61
R44- R62
R66-AD48
R67- V17
R68-AZ76
R69-AZ77
R71-AW66
R72-AW67
S20- P56
S26- P58
S28- R47
S33- P59
S49- P62
T02- P57
T06- Y50
T20- Y43
T21- Y46
T22- Y49
T37- R49
T38- Y48
Z33-AB50
Z34-AB49
Z35-AB48
Z36- I21
Z37- J21
Z38-AQ05
Z39- K21
Z40-AO09
Z41-AO40
Z42-AW46
Z43-AZ45
Z44-AZ49
Z45-AZ60
Z49- X25
Z50- X18
Z51- X04
Z52-BG78
AA33-AK08
AA34-AK12
AA35-AK28
AA36- I20
AA37- J20
AA38-AO04
AA39- K20
AA40-AO08
AA41-AO39
AA42-AW45
AA43-AZ44
AA44-AZ48
AA45-AZ59
AA46- I05
AA52-BI39
AB33-AF26
AB34-AF30
AB35-AF40
AB36-AE20
AB37-AF20
AB38- H10
AB39- H20
AB40- H30
AB41- H40
AB42- G30
AB43- G40
AB44-AE30
AB46-AC05
AB47- G11
AB52-BH78
AC51- H70
AD13-AG05
AD41- O41
AD42- O45
AD43- O49
AD44- N41
AE45-AG06
AE46-AG31
AE47-AI29
AE48-AI31
AE50-AI08
AE51-AI17
AE52-AI21
AF01-AI07
AF25-AK07
AF41- A03
AF42- A05
AF43- A07
AF44- A11
AF45-AD14
AF46-AD24
AF47-AD28
AF48-AD30
AF49-AD38
AF50-AF02
AF51-AF12
AF52-AF16
AF59- K68
AF63- K61
AF67- H66
AF71- K60
AI12- F42
AJ35- N70
AJ35- K70
AK16- H41
AO05- V36
AO06-AF28
AO10- A31
AO11-AZ19
AO14-AZ24
AO15-AZ28
AO16-AZ29
AO18-AZ32
AO21-AZ38
AO24-BA01
AO25- L04
AO26-AD47
AO27-AD49
AO28- M28
AO29-AD51
AO30-AD46
AO37- A29
AO41-AJ32
AP04-AQ30
AP12-AZ21
AP13-AZ22
AP15-AZ30
AP19-AZ35
AP20-AZ36
AP23-BA02
AP24-BA03
AP67- L31
AQ04- V35
AQ10- W31
AQ15-AR26
AQ25-AD45
AQ26- L13
AQ27- L23
AQ28-AD50
AQ29-BA55
AQ31- W52
AQ36- W39
AQ37- W40
AQ79- R39
AT18-BA40
AZ46-AE28
AZ47-AE29
AZ65-AR14
AZ66-BI54
AZ67-BI70
AZ68-BL60
AZ69-BI38
AZ71-BI39
AZ72- V23
AZ73- M15
AZ74-BA47
AZ75- X06
AZ78-AC15
AZ79-AC29
AZ80-AH09
BA69-BI79
BA70-BI58
BB66-BJ54
BB67-BJ70
BB69-BJ79
BB70-BJ58
BB71-BH77
BB75- L70
BB76- G19
BB77- G25
BI39-BH56
BL31- X71
BL32- X67
BL33- X63
BL34- X59
BL40- E57

IBM

INTERNATIONAL BUSINESS MACHINES CORPORATION
ACCOUNTING MACHINE, TYPE 407, CONTROL PANEL DIAGRAM

Form 22-6275-5
Printed in U.S.A.



REPORT ______ R V MIDDLETON ______ DIAGRAM NO. 650 UTILITY PANEL ______ DATE ______

TYPE 407 UTILITY PANEL -- CONTINUED

S19- P51- P46
S24- P48- P54
S34- P53- X46
T36- P49- W52
Q47- P52- X45
S44- P47- P61

U43- Y51- Y52
V49- R52- Q61
V50- R53- Q62
AP11-AO12-AZ20
AP14-AO13-AZ23
AP16-AO17-AZ31

AP17-AO19-AZ33
AP18-AO20-AZ34
AP21-AO22-AZ39
AP22-AO23-AZ40
BA66-BI35-BA67
BB68-BI36-AZ70

T03- T19- T35- W47
S18- S39- U01- U22- X43- P41
S23- T25- U06- U27- X44- P42

W43- W44- W45- W46- W51
S27- T08- T29- U10- U31- P43
S32- T13- T34- U15- U36- P44

TYPE 533 UTILITY PANEL

THIS PANEL WILL READ

12 IN COL 1	LOAD HUB CARDS
A READ	OPEN FOR TEMPORARY WIRING
B READ	REGIONAL INSTRUCTION CARDS
C READ	FIVE-FIELD LOADER CARDS

THIS PANEL WILL PUNCH

A PUNCH	OPEN FOR TEMPORARY WIRING	
B PUNCH	MACHINE LANGUAGE TRACE	10TH WORD IS 88808 00000
	FLAIR TRACE	88808 08000
	LOAD HUB CARDS FROM PUNCH WORDS 1 TO 8	88808 88000
C PUNCH	FIVE-FIELD LOADER CARDS	

WIRING FOR THIS PANEL IS SHOWN ON A 533 BOARD DIAGRAM WHERE CONVENIENT. OTHER WIRING IS LISTED BELOW BY TERMINALS ACCORDING TO THE DIAGRAM INDEX.

Z33- R10
Z34- L21
Z35- X14
Z36- Y08
Z37- Z02
Z38- Z16

Z39-AA10
Z40- A33
Z21-AC10
H42- W42
K42- V42
AM43- X47

W59-AL45
W60- Q50
W61-AL46
AM44- Q45
AM45- Q49
AM46- Q51

AK44- L42
AK45- M41
AK46-AD60
AP59- D43
AP61- R30
AQ61- S38

S28- R41
AA21-AC15
AN14- L09
AL44- W55
Y33- L06
X21- V05

S23- X35
D22- X40

Y35- U05-AE07
Y36-AB05-AF07

Y37-AB10-AG07
Y38-AB15-AH07

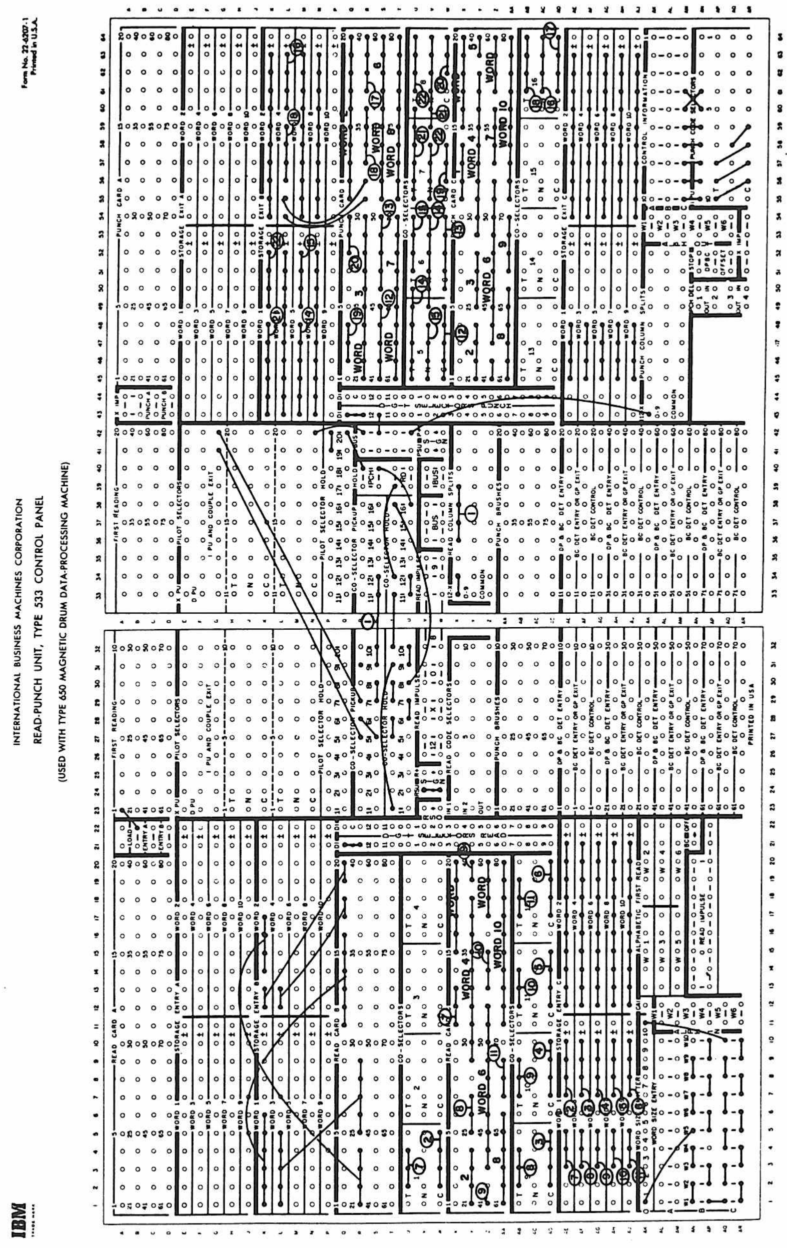
Y39-AB20-AI07
S41-AP60-AR61

T42-AB60- N41
V41- W41-AR55-AR60

AC03-AC08-AC13-AC18-AD21
W21-AE01-AF01-AG01-AH01-AJ01
AN13- K07- K08- K09- L07- L08
V31- K18- K19- K20- K21- L20
V30- L14- L15- L16- K10- L10

W31- Y34- L17- L18- L19
W30- Y04-AC04-AC09-AC14-AC19
V21- V02-AC02-AC07-AC12-AC17-AC20
Y21-AE02-AF02-AG02-AH02-AJ02-AC05

CORRECT TYPE 533 PANEL SO WORD 5 OF B READ HAS A WORD LENGTH OF 2.



FLAIR - FLOATING ABSTRACT INTERPRETATIVE ROUTINE

ONLY A BRIEF SUMMARY OF THIS SYSTEM IS GIVEN HERE. IT IS INTENDED TO SHOW DEVIATIONS FROM THE ORIGINAL SYSTEM AS PUBLISHED ELSEWHERE. A LISTING OF THE INSTRUCTIONS AND CONSTANTS IS FURNISHED TOGETHER WITH ENOUGH DESCRIPTIVE MATERIAL TO OPERATE THE SYSTEM WITHOUT GOING INTO SPECIFIC DETAIL. DETAILED BREAKDOWNS OF THE INDIVIDUAL ROUTINES ARE AVAILABLE IN THIS SAME FORMAT FOR THOSE INTERESTED OR HAVING A NEED TO ALTER. ADDRESS A REQUEST TO THE MATHEMATICAL ANALYSIS SECTION - MISSILE SYSTEMS DIVISION LOCKHEED AIRCRAFT CORPORATION - 7701 WOODLEY AVENUE - VAN NUYS CALIFORNIA.

FLAIR IS A PSEUDO-THREE-ADDRESS FLOATING POINT COMPUTING SYSTEM FOR USE ON THE TYPE 650. NUMBERS ARE OF THE FORM

PP .XXXXXXXX   WHERE PP IS 50 + THE ASSOCIATED POWER OF 10

ARITHMETIC COMMANDS ARE OF THE FORM

OP α β WHERE α AND β ARE FOUR DIGIT ADDRESSES

LOGICAL AND SUB-ROUTINE COMMANDS ARE OF THE FORM

0γ α β WHERE α AND β ARE FOUR DIGIT ADDRESSES

THE γ IN THE ARITHMETIC COMMANDS REPRESENTS THE UNITS DIGIT OF THE 10 RESULT STORAGES 0000 TO 0009. THESE ADDRESSES ARE A PART OF FLAIR AND MAY BE USED ONLY FOR THIS TEMPORARY PURPOSE. THE BLOCK TRANSFER COMMAND 8γ FREES THEM FOR FURTHER USE.

THE FLAIR SYSTEM IS UNDER THE CONTROL OF THE WORD IN 1615. THE D PART OF THIS WORD IS THE ADDRESS OF THE FLAIR COMMAND TO BE OBEYED. COMMANDS ARE OBEYED IN SEQUENTIAL ORDER EXCEPT AFTER TRANSFER COMMANDS. ENTER FLAIR BY RESET ADDING A WORD 17 J 1735 TO 8003 AND OBEYING 8003. J IS THE ADDRESS OF THE FIRST FLAIR COMMAND TO BE OBEYED.

THE ENTIRE SYSTEM OCCUPIES THE ADDRESSES FROM 1300 TO 1999. THE ARITHMETIC PORTION PLUS SQUARE ROOT AND ABSOLUTE VALUE OCCUPY THE ADDRESSES FROM 1600 TO 1999 AND MAY BE USED IN THIS ABBREVIATED FORM. IF LESS THAN THE FULL COMPLEMENT OF SUBROUTINES IS NEEDED - USE ARITHMETIC FLAIR PLUS GROUPS OF STORAGES AS INDICATED.

LOG	1500 - 1599
ANTILOG	1450 - 1599
SINE AND COSINE	1350 - 1449
ARCTANGENT	1300 - 1499

TRACING IS UNDER THE CONTROL OF THE CONSOLE. SETTING THE HUNDREDS SWITCH OF 8000D TO AN 8 CAUSES TRACING. A 9 IN THIS POSITION CAUSES THE TRACING TO BE IGNORED AND FLAIR WILL RUN NORMALLY. THE MACHINE WILL STOP IF A DIGIT OTHER THAN AN 8 OR 9 IS INADVERTENTLY SET IN THIS SWITCH. IF THE PROGRAM IS IN FLAIR IT MAY BE RESTARTED BY

1. DEPRESSING PROGRAM RESET BUTTON
2. SETTING THE SWITCH PROPERLY
3. TRANSFER TO 1735 FOR NEXT COMMAND

FLAIR — CONTINUED

FLAIR OPERATION SUMMARY - LOGICAL COMMANDS

00 - 06	NO OPERATION. THE NEXT COMMAND OBEYED IS IN β
01	MACHINE STOP. IF PROGRAM START BUTTON IS DEPRESSED THE NEXT COMMAND OBEYED IS IN β
02	NO OPERATION. NEXT SEQUENTIAL COMMAND IS OBEYED.
03	CONDITIONAL TRANSFER ON THE SIGN OF THE CONTENTS OF α THE NEXT COMMAND OBEYED IS IN β IF THE SIGN IS - THE NEXT COMMAND OBEYED IS SEQUENTIAL IF THE SIGN IS +
04	CONDITIONAL TRANSFER ON RELATIVE ZERO - SEE DETAILED ITEM.
05	UNCONDITIONAL TRANSFER OUT OF FLAIR. THE NEXT COMMAND OBEYED IS THE MACHINE LANGUAGE COMMAND IN α. IF THE RETURN TO FLAIR IS AT 1612 THE NEXT FLAIR COMMAND IS SEQUENTIAL TO THE 05 COMMAND. IF THE RETURN IS AT 1792 IT IS FOUND IN β OF THE 05 COMMAND.
07 TO 09	NO OPERATION. MACHINE STOP - THEN SEQUENTIAL COMMAND.

FLAIR OPERATION SUMMARY - ARITHMETIC COMMANDS

1γ	$(\alpha) \cdot (\beta) + (\gamma) \longrightarrow \gamma$	
2γ	$(\alpha) \cdot (\gamma) + (\beta) \longrightarrow \gamma$	
3γ	$(\alpha) + (\beta) \longrightarrow \gamma$	
4γ	$(\alpha) - (\beta) \longrightarrow \gamma$	
5γ	$(\alpha) \cdot (\beta) \longrightarrow \gamma$	
6γ	$-(\alpha) \cdot (\beta) \longrightarrow \gamma$	
7γ	$(\alpha) \div (\beta) \longrightarrow \gamma$	
8γ	$(\alpha+K) \longrightarrow (\beta+K)$	K MAY VARY FROM 0 TO γ

FLAIR OPERATION SUMMARY - SUBROUTINE COMMANDS

90	$\sqrt{(\alpha)} \longrightarrow \beta$	
91	$\mathrm{SIN}\ (\alpha) \longrightarrow \beta$	ARGUMENT IN RADIANS
92	$\mathrm{COS}\ (\alpha) \longrightarrow \beta$	ARGUMENT IN RADIANS
93	$\mathrm{ARCTAN}\ (\alpha) \longrightarrow \beta$	
94	$\mathrm{LOG}\ (\alpha) \longrightarrow \beta$	
95	$\mathrm{ANTILOG}\ (\alpha) \longrightarrow \beta$	
96	$\lvert(\alpha)\rvert \longrightarrow \beta$	
97 TO 99	NO OPERATION. NEXT SEQUENTIAL COMMAND IS OBEYED.	

MACHINE STOPS

9000	SQUARE ROOT OF A NEGATIVE NUMBER
9001	SINE OR COSINE OF AN ANGLE GREATER THAN 100 RADIANS
9004	LOG OF ZERO OR A NEGATIVE NUMBER
9005	POWER OF 10 INDEX OUT OF RANGE

Dec. 13, 1955 **E. BUHLER** **2,726,940**

XEROGRAPHIC PRINTER

Filed Nov. 3, 1954 7 Sheets-Sheet 3

FIG. 6

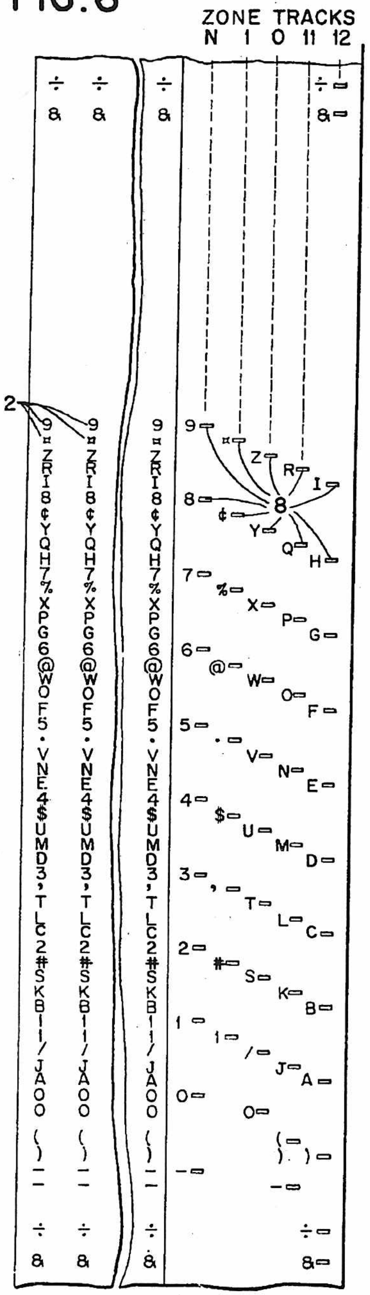


FIG. 7

ZONE	DIGIT	SYMBOL
1	9	¤
1	8	¢
1	7	%
1	6	@
1	5	·
1	4	S
1	3	·
1	2	#
1	1	|
0	9	Z
0	8	Y
0	7	X
0	6	W
0	5	V
0	4	U
0	3	T
0	2	S
0	1	/
11	9	R
11	8	Q
11	7	P
11	6	O
11	5	N
11	4	M
11	3	L
11	2	K
11	1	J
12	9	I
12	8	H
12	7	G
12	6	F
12	5	E
12	4	D
12	3	C
12	2	B
12	1	A
11	0	(
12	0	)
12	11	÷
	9	9
	8	8
	7	7
	6	6
	5	5
	4	4
	3	3
	2	2
	1	1
	0	0
	11	−
	12	&

INVENTOR.
EUGEN BUHLER

BY Joe L. Koerber

ATTORNEY

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Clell M. Brentlinger became a Mors
he while attending high school at Carlisle, Indian
ke or a time as an operator for the Evansville an
aute, Frisco and Chicago and Eastern Illinois Rail
mpanies. He was graduated from the University
wit the degree of B.S. in E.E. and joined Wester
mn liately thereafter. He has occupied the pos
Engineering Assistant, General Inspector, Genera
Supervisor, Division Traffic Superintendent of th
an Lake Divisions, and General Superintendent
anc s now Assistant General Manager of the Lak
. W le on the staff of the Vice President in charg
c, Mr. Brentlinger was for a few years concerne
marine cable operation, and was active in the tes
in duction of tape printers to replace the pag
or nally used on Multiplex trunk circuits, and
s and adoption of teleprinters. He now is primaril
d with railroad contract matters, employee rela
d dgets and forecasts. He is a member of E
Ju, member for life of AIEE, and served a three
m a member of the Board of Directors of th
Electronics Conference.

ROBERT W. HARRIS, Assistant to Systems Planning Engineer

Keyboard Standardization

In this country page teleprinters ushered in a new era of printing telegraphy following World War I; then, during the 1920's, a complete transition to tape teleprinters was effected. In recent years, Western Union has employed hundreds of page machines in special situations but now, in 1956, the company is about to revert to page reception in a large segment of public communications. How keyboard standardization makes this more practicable, how page and tape will work together for faster, more efficient, terminal handling, the ingenious control equipment and the new look in sprocket-feed page printers, is discussed. The modified teleprinter with its message safeguards and automatic number check, and the control equipment for sending positions, manual and automatic, have been developed and placed in trial service. Implementation of these developments through page receiving installations in major offices will follow. Meanwhile, the initial teleprinter keyboard conversion program involving only tape teleprinters, and perforators working with reperforator centers (about 10,000 units), has been virtually completed.

FOR NEARLY four decades high-speed record communications have depended primarily on printing telegraph. Other methods have been developed and successfully applied to supplementary services, but it is safe to say that, despite the rapid growth of facsimile telegraphs, permutation coded printing telegraph will remain the backbone of the telegraph industry for many years. Printing telegraphy in the U. S. A. has taken great forward strides since the mid-thirties through development of reperforation techniques and their application to the public message system. Manual reception and retransmission at relay points have been eliminated by the establishment of major reperforation centers, greatly improving the speed and efficiency of telegraph service. At destination points, however, all those messages on which physical delivery is required must be processed manually to produce a Western Union telegram.

Quite generally today the yellow blank familiar to millions carries its message on printed tape secured to it by adhesive and more than 300 million feet of the gummed tape were required last year to serve the nation's business and social communications needs. Obviously, if these messages were received on page printers the time required for tape gumming would be eliminated, a fact recognized as far back as 1915 when printing telegraphy was introduced widely into the Western Union system, on a *page-printer* basis.

Tape teleprinter was designed to meet Western Union specifications

To those familiar with telegraph problems, the conversion from the page to the tape method which took place in the early twenties might appear unwise. The decision was reached, however, only after thorough study and analysis of operating problems. Inherent in the tape method is the ease with which corrections may be transmitted and applied to the received copy as "paste-overs" thus avoiding "reruns", the elimination of the line signals required for the carriage functions, and lower first cost and maintenance of equip-

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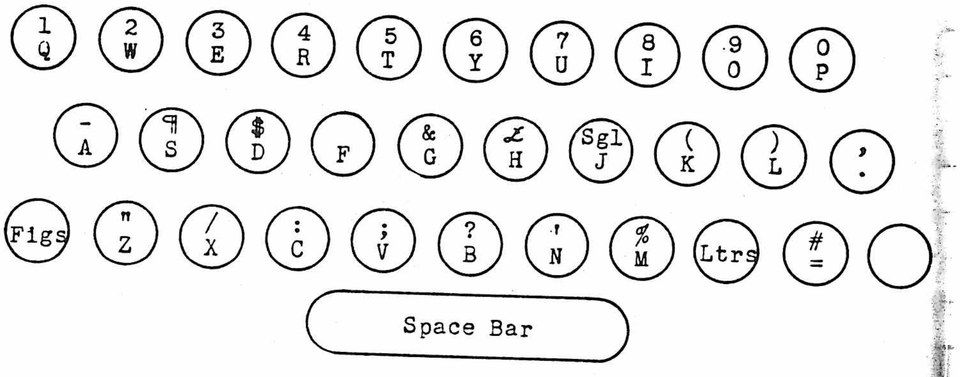


Keyboard arrangement used many years with tape teleprinters, which needed no carriage-return or line-feed functions. Keys S, F, (.) , N, M, =, were unlike page teleprinter keys

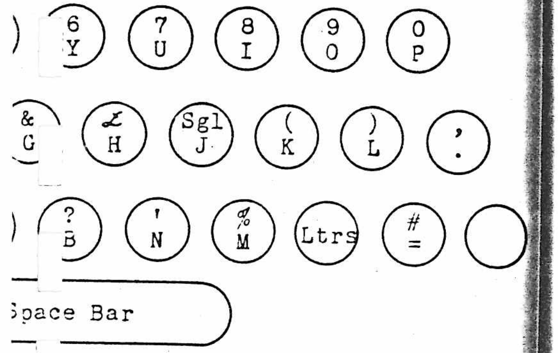
ment. These factors all contributed to the decision to replace the early and less perfected page printers with tape machines.

Technological advances in equipment, circuitry and especially transmission, and concurrent changes in operating practices over the past 30 years, however, have brought about a reversal of the relative positions of the tape and page teleprinter for circuit termination. Use of carrier circuits with improved means for multiplex synchronization largely eliminated errors resulting from line hits common on open line grounded wire circuits. With the excessive unproductive time required for "reruns" thus minimized, the page printer is destined again to play an important role in the company's communications system, as a receiver-only for many single trunk circuits and for groups of trunks operating on an unattended basis. The transition from tape to page is an important step forward in better record communications and it has involved many problems that have been satisfactorily solved.

A major problem of very wide scope in the transition from tape to page lay in the dissimilarity of the keyboards of the two types of teleprinters. These differences, mostly in upper-case characters, may be explained by the fact that code combinations affecting the carriage-return and line-feed functions were not needed for tape operation and could therefore be used for additional characters, including a "tape cut" signal to guide the receiving operator. Thus some improvement in operator production, both sending and receiving, as well as reduced line time, resulted from the rearrangement from the original page to the tape keyboard.

The need for systemwide compatibility of all teleprinter keyboards—which, incidentally, do not include any small roman letters—became apparent with the introduction of page printers for customers' tie lines and particularly following consummation of the Postal-Western Union merger in 1943. Interchange of traffic between teleprinters with nonmatching keyboards depended on a one-way tape-to-page translator or manual retransmission. As a first step toward keyboard standardization all Postal Type 14 tape printers were converted to Western Union tape standard. Further standardization to effect conformity between tape and page was then studied by an interdepartmental committee.

The findings of the committee stressed the urgency of making a systemwide conversion of keyboards to facilitate expansion of reperforator switching into the tie-line field and to permit exploitation of page-printer reception on public message circuits. The keyboard layout recommend was essentially a Western Union page type with bell signal on "J" bu included a "¶" on upper case "F". The purpose of "¶" is to facilitate original "punching" of tape on perforator or tape teleprinter keyboards, and ensure recognition of the paragraph on messages



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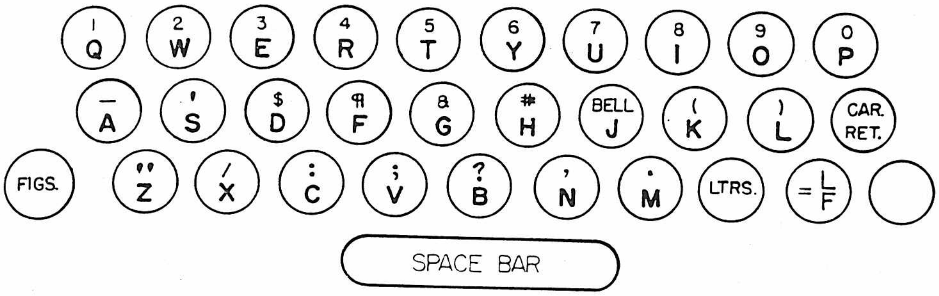


New standard key layout eliminates £ and %, places ¶ on upper-case F on tape keyboards, and ('), #, (,), (.), in same positions on both tape and page keyboards. Blank key perforates feed holes

received on tape printers. *Since tape or page reception of messages originating on page teleprinters is not facilitated by "¶", this character will not be installed on existing page printers.*

Conversion of teleprinter keyboards at first posed a difficult problem. Since compatibility must be maintained continuously and even temporary impairment of the service cannot be tolerated, it appeared that keyboard conversion would have to be carried out in its entirety over a relatively short period. The first plan contemplated keyboard conversion at all functional offices including reperforator centers during a Saturday-Sunday period, tributary circuits over a 90-day period, and manual circuits as rapidly as circumstances permitted. During conversion, operators were to be required to send "PAR" for "¶", "APOS" for (') and "NBR SIGN" for "#". Tie-line switching was to be discontinued until tributary offices all were converted. With some 35,000 printers involved, the cost of this conversion program and the labor and operational difficulties entailed led naturally to a careful consideration of all possible alternatives.

Further study developed a practicable *modus operandi* for converting, and only the 10,000 units associated directly with the reperforator system were included in the standardization. The conversion extended over a period of about a year and the work was divided into two distinct steps. Use of certain upper-case characters was discontinued so that converted and unconverted keyboards could work together indiscriminately. After the changes had been effected on all equipment involved, the upper-case characters were used in their new locations, thus making the old locations available for installing the remaining slugs to complete the conversion. The first step comprised the following changes:

PRESENT			PROPOSED		
LOWER CASE		UPPER CASE	LOWER CASE		UPPER CASE
F	—	Blank	F	—	¶
H	—	£	H	—	#
M	—	%	M	—	;
S	—	¶	S	—	;

Temporary stick-on key cap covers were provided for use during the conversion stage. The temporary covers for the letters F, H, M and S showed no upper case characters. Paragraph was punched "= 5 spaces."

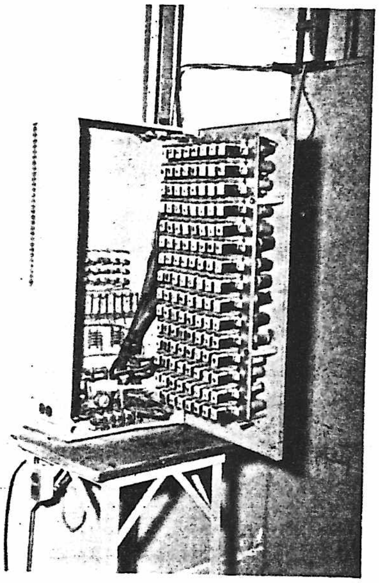
The second stage comprised the following changes:

PRESENT			PROPOSED		
LOWER CASE		UPPER CASE	LOWER CASE		UPPER CASE
N	—	'	N	—	,
=	—	#	=	—	=

Since all key cap changes were made during the first conversion step, it was necessary to provide temporary key cap covers to show the old markings for the N, period and equals sign keys. Stick-on key cap covers showing upper-case N-blank replaced the first temporary key cap covers showing upper-case apostrophe ('), during the second stage of the conversion period.

Implementation of the recommendations of the committee followed formulation of a method for unattended page-printer operation. Very real savings were forecast for this project of which keyboard standardization constituted a first and important step. Some serious problems in addition to keyboard standardization per se were presented in the related development of unattended page-printer operation and "From Tie-Line" page-printer switching.

Decision on an over-all operating method was prerequisite to inauguration of the keyboard conversion program. There is a common misconception of operation of mixed tape and page printers with standard keyboards. A "tape" originating message cannot be received on a page teleprinter unless the message has been prepared in anticipation of such reception by a character count and insertion of carriage-return and line-feed signals wherever needed. This is because automatic carriage return and line feed is not practicable on any *standard* page printer. Due to the inertia of the carriage the travel time for a full line is in excess of the time to send one character (space), and even with a short line, dash-pot operation wit attendant carriage "bounce" produces a irregular left margin.



Page-printer control unit at the sending end

Because of this situation, two alternative solutions were weighed; i.e., preparing all messages with carriage returns and line feeds or introducing these functions automatically at the point of direct transmission to the receiving page printer. The latter plan was adopted to save operating labor and to reduce the possibility o human error. Increased operator "punching" time of about eight percent was forecast with original preparation in page form and, because the major portion o Western Union's traffic flows through a reperforator center which places the sending and receiving ends out of direct contact, any failure by the sending operato to punch "CR" (carriage return) or "LF" (line feed) would result in an undeliverable or undecipherable message. In addition, all originating points would requir character counters, to ensure prope length lines on messages received on pag printers. These have a character spacing o 10 letters to the inch instead of the 8-to-the-inch spacing which is standard on tap machines. Again, necessity for countin lines would place a further burden on th operator punching tape at the point o origin. The received copy would still no be produced in the preferred form for delivery which requires that the identifyin number appear at the beginning of th "top" line, and long message receptio would involve a difficult problem. Thus will be appreciated that development o the page-printer control unit at the sending end was an essential part of the keyboard standardization — page printe program.

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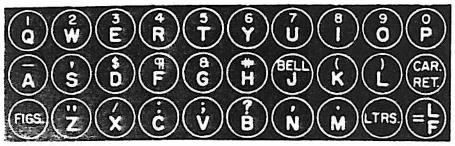
There are inherent weaknesses in roll paper for public message service. Besides the disadvantage of having a variety of lengths of blanks, platen slippage, an uncontrollable variable, produced variations in these "standard" length sheets. While side-masthead paper was satisfactory for tie lines, Western Union naturally preferred to use its long established and widely advertised standard receiving blank. Also there was a problem with paper curling at the interior of the roll, which interfered with intra-office message transit on belt conveyors. It was obvious that the new application for page printers demanded a new approach printerwise.



Final key caps were furnished in sheets as semi-punched discs showing white letters. Part of a sheet is shown

Consideration was then given to so-called fanfold margin-punched perforated paper and sprocket-feed printers. It was found practicable to design a message separator, employing principles embodied in commercial "bursters", which could be attached to the printer cover. By reducing line spacing from three to four lines to the inch, several important objectives were gained. Platen circumference of 5½ inches matched the standard 5½-inch commercial form punched paper, an even multiple of ¼-inch line separation. Thus the "burster" motor could be triggered by platen mounted contacts. Utilization of standard spaced perforations meant large savings in cost of paper message forms because manufacturing equipment is available for volume production of such forms. A further advantage of four lines to the inch lies in reduced paper area for any given quantity of intelligence. Thus scanning time is reduced on messages for Telefax terminal handling.

Because printers will be operated in groups entirely unattended except for editing the received copy at a single editing RQ and routing position, new safeguards were needed. Operating requirements established the following minima which were successfully developed:

1. The call letters and sequence number of each message should be checked.
2. Assurance should be given that a piece of paper comes out of the printer for each message number checked.
3. Each piece of paper should bear an identification showing the printer from which it was ejected.
4. The platen and paper must be in register with respect to the heading.
5. Failure to meet any of the above requirements shall de-activate the received number indicator and bring up an alarm. The message involved plus all ensuing messages should be held at the teleprinter until manually checked and released.

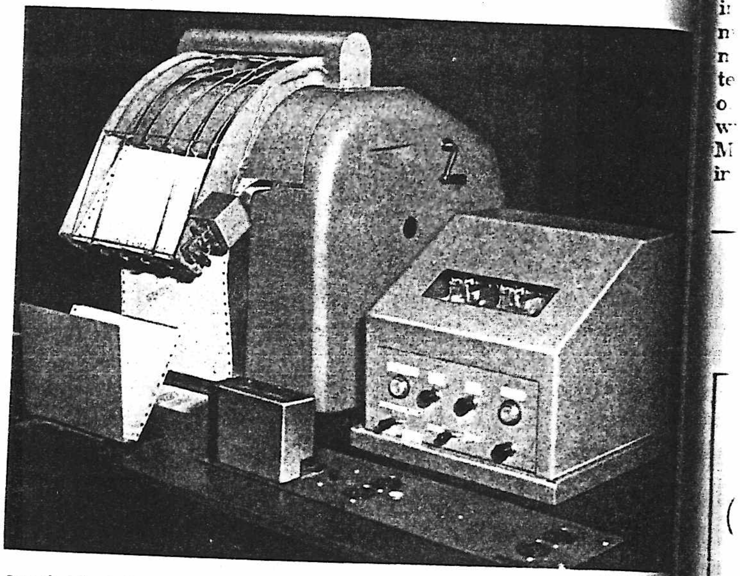
The page-printer control unit was a collateral development with the printer modification. This equipment, consisting of three relay banks and one relay-and-rotary switch bank, is associated with the line sending position at the reperforator or manual office. It controls the transmitter, reads the tape fed to it and generates appropriate CR-LF signals.

Sequence of operation is as follows: When the first intelligence in the tape is encountered at the transmitter pins, the transmitter is stopped and time and date requested. A standard "chronitor" transmits time and date directly to line and the tape is started. The control unit then reads the tape to detect the identifying number which always follows automatic numbers, and sends CR-LF so that the identifying number will appear at the beginning of the second line. Equals signs which follow filing time, name to, destination, body and signature are converted to CR-LF to produce a message in orthodox form for physical delivery. Carriage return-line feeds required for the body of the message are generated following a character count of each line. The number of characters (excluding Figures, Letters and Blanks) in each line are counted on a rotary switch, and CR-LF is inserted following the first space character encountered after 58 characters have been tallied. If a space does not occur by the time 70 characters are counted, CR-LF will be inserted following the 70th character. This prevents piling up at the end of a line.

Whenever a CR character is read in the tape, the following character is examined and if it is not a LF, a LF is generated and transmitted to line. Fortuitous occurrence of CR would otherwise cause overlining on the received printer copy. If a CR-LF combination is read at the end of the top line, the message is identified as originating on a page printer and passed to the receiving teleprinter per copy. Paragraph sign is converted into CR-LF five spaces.

All message lines are counted and at the end-of-message signal (CR-CR), line feeds are generated so that a total of 22 will be transmitted to line to advance the paper into registration, for receipt of the next message. If CR-CR is not encountered before 16 lines are tallied (a lon message), transmission of the message momentarily stopped and sufficient li feeds are transmitted to register the pap correctly for the second sheet. Thus a long messages are contained on multipl of the standard size form.

Application of sprocket-feed burste equipped page printers to branch offic and tributaries and for private wi services involves other problems, but ke board standardization and the bas development of applying page printers Western Union internal operations ha been completed and plans for exploitatio are well under way.



Sprocket-feed, "burster" equipped page teleprinter produces telegrams of unifor size with conventional headings. Unit at right assures correct message numbe paper registration ered before 16 lines are tallied (a lon message), transmission of the message i momentarily stopped and sufficient lin eeds are transmitted to register the pape correctly for the second sheet. Thus al long messages are contained on multiple f the standard size form.

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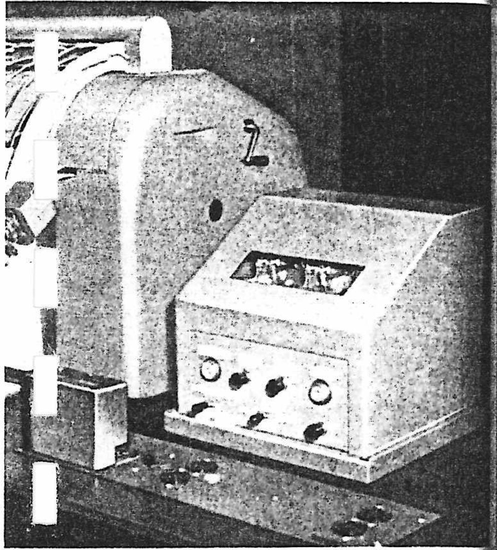

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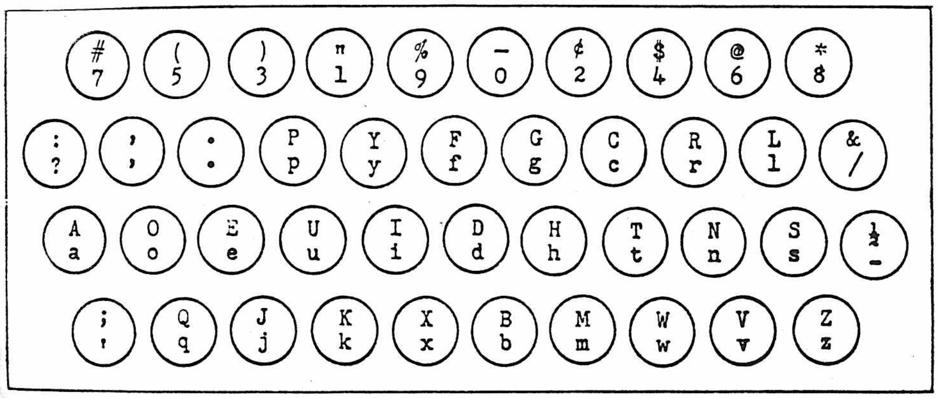
Robert W. Harris, Assistant to the Systems Planning Engineer, is a graduate of the Columbia University School of Mines, Engineering and Chemistry where he received the degree of Mechanical Engineer. During World War I he served in the Air Service, Signal Corps, as a pursuit pilot. He joined the staff of the Traffic Engineer in 1921, and subsequently moved to the Systems Development Division of the Development and Research Department. Mr. Harris has long been active in studies of improved telegraph methods and services extending over a broad field of interest, where correlation of research and development with operating requirements has been a prime requisite. More recently, the Keyboard Standardization project is one in which he has played a major part.

DVORAK'S TYPEWRITER KEYBOARD LAYOUT REVIVED



Over 20 years ago Western Union examined a typewriter keyboard layout arranged by Comdr. August Dvorak, USN, to improve distribution of work load between the right and left hands and among the various fingers.

Navy Department tests of the Dvorak keyboard were publicized in 1945 and new tests proposed by the Government's General Services Administration received considerable newspaper notice recently.

Although previous tests showed marked increases in typing efficiency and accuracy, it generally was considered impractical to retrain operators and rebuild machines.